A HISTORY OF INDIAN LITERATURE

DAVID PINGREE

JYOTIḤŚĀSTRA

ASTRAL AND MATHEMATICAL LITERATURE

OTTO HARRASSOWITZ · WIESBADEN

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INTRODUCTION

Traditionally *jyotiḥśāstra* is divided into three *skandhas: saṃhitā* (omens), *gaṇita* (astronomy), and *horā* (astrology) (see BS 1, 9); and, according to the medieval *muhūrta* treatises, was originally promulgated by the eighteen sages Brahmācārya, Vasiṣṭha, Atri, Manu, Paulastya, Romaśa, Marīci, Aṅgiras, Vyāsa, Nārada, Śaunaka, Bhṛgu, Cyavana, Yavana, Garga, Kaśyapa, Parāśara, and Sūrya. The validity of the first tradition was maintained only by artificially including new forms of scientific writing—e.g., treatises on mathematics, on *muhūrta*, or on *praśna*—in one or another of the three *skandhas*, while there was never any validity to the second. In this volume an attempt has been made to establish a more accurate classification of the areas of *jyotiḥśāstra* actually made the subject of independent works, and to survey the literature in each area (but omitting the sectarian Jaina contributions) in order to establish a correct historical origin (often from outside of India) and development of each. To have included discussions of the technical aspects of these sciences, however, would both have duplicated much that has already been done (though in some areas it desperately needs to be done better) and have extended the length of this volume far beyond reasonable bounds.

Nor has any attempt been made to deal with the literary qualities of the works discussed. The primary texts are certainly all in metrical form, but are generally written in a very crabbed and obscure style designed to stimulate the student's memory of the procedures to be followed, but frequently not even pretending to provide the full algorithm for solving a particular problem; that was to be found, if not in the repetitiousness of the science, in the guru's oral tradition or in the prose commentary. Thus, while cleverness and imprecision both abound in this poetry, the normal canons of *alaṅkāra* are simply not applicable; only rarely, as in the *ṛtuvarṇana* in Bhāskara's SŚB, is any poetic feeling made manifest.

Two of the difficulties generated by the use of a poetic form were the necessity of expressing numbers metrically, and the difficulty of maintaining a fixed technical vocabulary. The latter impediment led to the invention of many synonyms, and the use of single terms in several different, if related, senses; this, of course, increased the ambiguity and imprecision inherent in a system where the texts' purpose is to jog the memory rather than to teach the complete course. The former problem was solved in two ways: by using common objects that appear or are understood to appear in the world in fixed quantities as synonyms for those quantities (e.g., "eyes" are "two," "fires" are "three," "Vedas" are "four"), and by using *akṣaras* to refer to numbers. The former system, called the *bhūtasaṅkhyā*, already appears in the third century in Sphujidhvaja's Yavanajātaka. Sphujidhvaja also seems to be the

first to use a symbol for zero *(bindu)* in the decimal place-value system (YJ 79, 6 and 7), though, of course, a dot or a circle had been used previously by both Babylonians and Greeks in the sexagesimal place-value system to represent a place with no other number in it. Āryabhaṭa invented a different way of expressing numerals, in which the consonants of the Sanskrit alphabet are used to indicate the numbers and the vowels their places (up to eighteen); unfortunately, the "words" formed thus were often unpronounceable and in any case had no meaning other than the numerical one. A different system was invented in South India that obviated this difficulty. The *kaṭapayādi* system (in which k, ṭ, p, and y equal 1 regardless of the vowel they are followed by) uses the consonants as equivalents of the numbers 1 to 9 and 0; four varieties of this system are known. A clever *jyotiṣī*, then, can construct verses that are superficially on one subject while each sequence of consonants can be read as a significant number; a good example of this is Parameśvara's Haricarita.

The following pages will show that our knowledge of Indian *jyotiḥśāstra* is rather spotty. This is due both to the accidents that cause the preservation (and availability) of one text rather than another, and to the lack of reliable and accurate descriptions of the many unpublished manuscripts. The second disability is being slowly alleviated as CESS progresses; I have generally referred the reader to it, when available, for information about an author, his works, and what modern scholars may have said about them, though I have attempted in all cases to give reasonably complete listings of published editions as they are a useful guide to modern interests. Those modern interests lie overwhelmingly in *jātaka, tājika, muhūrta, praśna,* and various forms of divination; classical astronomy and mathematics had virtually ceased to be studied or taught by the end of the nineteenth century. A new group of Indian and foreign scholars has, however, begun to work in these areas since World War II; and, while much is still unfortunately published that is of little or no value, some progress toward an understanding of the origins and developments of these sciences has been made. I hope that this volume will stimulate more serious interest in this field.

Chapter I

ŚULBASŪTRAS

In the performance of Vedic *śrauta* rituals an essential prerequisite is the piling up of the fire altar *(agnicayana)*. These altars *(citis)* take the form of various objects; the forms mentioned in Taittirīyasaṃhitā 5, 4, 11 (after the *chandaściti*[1] or "meter altar") and the sacrificers who should erect them are:

1. *śyenaciti* or "hawk altar"[2] by one desiring heaven *(suvarga)*;
2. *kaṅkaciti* or "heron altar" by one desiring a head in the other world;
3. *alajaciti* or "*alaja*-bird altar" with four furrows by one desiring support;
4. *praügaciti* or "triangle altar" by one desiring to repel his foes;
5. *ubhayataḥ praügaciti* or "triangle on both sides altar" by one desiring to repel both present and future foes;
6. *rathacakraciti* or "chariot-wheel altar" by one wishing to defeat his foes;
7. *droṇaciti* or "trough altar" by one desiring food;
8. *samūhyaciti*[3] or "things to be gathered together altar" by one desiring cattle;
9. *paricāyyaciti*[4] or "circle altar" by one desiring a village;
10. *śmaśānaciti*[4] or "cemetery altar" by one desiring the world of the fathers *(pitṛloka)*.

A few other altar-shapes are described in other Brāhmaṇas, where also are prescribed the rituals to be performed at these altars. The Śrautasūtras belonging to the Yajurveda often include as appendices treatises that give rules concerning the geometry involved in the construction of these altars. These treatises are known as the Śulbasūtras.[5]

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[1] An imaginary altar constructed in the sacrificer's mind, but with the recitation of the appropriate mantras.

[2] Called *suparṇaciti* in ŚB. 6, 7, 2, 8. This is the principle altar shape of which the others were regarded as derivatives.

[3] Called the *samuhyapurīṣaciti* in ŚB.

[4] Omitted by ŚB.

[5] See B. Datta, The Science of the Śulba, Calcutta 1932; A. Michaels, Beweisverfahren in der vedischen Sakralgeometrie, Wiesbaden 1978; and T. A. Sarasvati Amma, Geometry in Ancient and Medieval India, Delhi—Varanasi—Patna 1979, pp. 14—60. Still informative is G. Thibaut, "On the Śulvasútras," JASB, NS 44 (1875), 227—275.

The Śrautasūtras containing Śulbasūtras are those of Baudhāyana,[6] in which the Śulbasūtra is *praśna* 30;[7] of Āpastamba,[8] in which the Śulbasūtra is also *praśna* 30;[9] of Vādhūla,[10] whose Śulbasūtra is said to survive in a manuscript at Madras;[11] of Mānava,[12] in which the Śulbasūtra is adhyāya 10[13] (a recension of this is entitled the Maitrāyaṇīyaśulbasūtra[14]); of Varāha,[15] whose Śulbasūtra survives in a manuscript at Mysore;[16] and of Kātyāyana,[17] in which the Śulbasūtra is *pariśiṣṭa* 7.[18] The last of these belongs to the Śuklayajurveda (the Vājasaneyisaṃhitā), the first five to the Kṛṣṇayajurveda (Baudhāyana, Āpastamba, and Vādhūla to the Taittirīyasaṃhitā, and Mānava and Varāha to the Maitrāyaṇīyasaṃhitā).

Precise dating of any of these texts is impossible. The earliest, that of Baudhāyana, was perhaps written before 500 B.C., and the remainder presumably antedate the Christian era. It was, indeed, during this period also, probably in the second century B.C., that the most striking *śyenaciti* of which remains survive was built in Kauśāmbī.[19] The Āpastamba appears to be the second oldest of the major Śulbasūtras, and the Kātyāyana, which consists of

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[6] J. Gonda, The Ritual Sūtras, Wiesbaden 1977, pp. 514—518.

[7] Edited with the commentary, Śulbadīpikā, of Dvārakānātha Yajvan by G. F. Thibaut, "The Sulvasutra of Baudháyana with the Commentary of Dvárakánáthayajvan," The Pandit 9—10 and NS 1 (1874/75—1876/77); by W. Caland, BI 163, vol. 3, Calcutta 1913, pp. 389ff.; and by S. Prakash and R. S. Sharman, New Delhi 1968.

[8] Gonda, pp. 520—521.

[9] CESS A1, 50a. Edited with a German translation and a commentary by A. Bürk, "Das Āpastamba-Śulba-Sūtra," ZDMG 55 (1901), 543—591, and 56 (1902), 327—391; and, with the commentaries of Kapardisvāmin, Karavinda, and Sundararāja, by D. Srinivasachar and S. Narasimhacar, MSS 73, Mysore 1931, and by S. Prakash and R. S. Sharma, New Delhi 1968.

[10] Gonda, pp. 522—524. The Āpastamba is closely related to a section (*praśna* 25) of the Satyāṣāḍhaśrautasūtra; see Michaels, pp. 173—180.

[11] N. K. Majumdar, "On the Different Śulba Sūtras," PAIOC 2 (1923), pp. 561 to 564.

[12] Gonda, pp. 525—526.

[13] Edited and translated by J. M. van Gelder, The Mānava Śrautasūtra, 2 vols., New Delhi 1961—1963. See also N. K. Mazumdar, "Mānava Śulba Sūtram," JDL/U Calcutta 8 (1922), 327—342.

[14] Datta, p. 6.

[15] Gonda, p. 527.

[16] Datta, pp. 6 and 230.

[17] Gonda, p. 528—529.

[18] An incomplete edition with the Śulbasūtravṛtti of Rāma was published by G. F. Thibaut, "Katyayana Śulbapariśishṭa, with the commentary of Ráma, son of Súryadása," The Pandit, NS 4 (1882); edited with the commentaries of Karka and of Mahīdhara by G. S. Nene and A. S. Dogre, KSS 120, Benares 1936; and by S. D. Khadilkar, Poona 1974.

[19] G. R. Sharma, The Excavations at Kauśāmbī (1957—59), Allahabad 1960, pp. 87—126; on the interpretation of this monument see D. Schlingloff, "Menschenopfer in Kauśāmbī?," IIJ 11 (1969), 175—189.

a *sūtra* section (to a large extent repeating *sūtras* of the Āpastamba verbatim), followed by a verse section, is among the latest; the Mānava has apparently copied some verses from the Kātyāyana.

Each of the basic altars must be constructed with five layers of bricks, and there must be a fixed number of bricks in each layer; moreover, the bricks in the second and fourth layers must not be directly above or below those in the first, third, and fifth layers. And the surface covered by the altar, regardless of its shape, must cover an area of seven and one half square *puruṣas* or, for certain purposes, that area increased by specified numbers of square *puruṣas*, or it must be multiplied by a given factor. Finally, the altar must be correctly oriented with respect to the cardinal directions. The task faced by the authors of the Śulbasūtras was to prescribe rules for laying out these altars with only a rope *(rajju* or *śulba)* of determined length and posts or gnomons *(śaṅku)*.[20] The geometrical problems that were solved by these altar-builders are indeed impressive, but it would be a mistake to see in their works the unique origin of geometry;[21] others in India and elsewhere, whether in response to practical or theoretical problems, may well have advanced as far without their solutions having been committed to memory or eventually transcribed in manuscripts.

The solutions utilized by the *sūtrakāras* involve the knowledge of a number of specific right-angled triangles (e.g., 3, 4, 5; 5, 12, 13; 7, 24, 25; 8, 15, 17; 12, 35, 37; and 15, 36, 39) as well as the general rule that the square on the diagonal of a rectangle (square or oblong) is equal to the sum of the squares on two sides; of the approximation

$$\sqrt{2} \approx 1 + \frac{1}{3} + \frac{1}{3 \times 4} - \frac{1}{3 \times 4 \times 34};$$

and the radius, r, of a circle whose area is approximately equal to a square of side x:

$$r = \frac{x}{2} + \frac{\frac{x}{2} \cdot \sqrt{2} - \frac{x}{2}}{3}.$$

They also give particular solutions to certain indeterminate equations, though without any hint at the method by which they arrived at them.[22]

The Baudhāyanaśulbasūtra in the edition by Prakash and Sharman contains ten *adhyāyas* divided into 21 *khaṇḍas* (4, 3, 2, and 6 *khaṇḍas* in the first four

[20] A. K. Bag, "The knowledge of Geometrical Figures, Instruments, and Units in the Śulbasūtras," EW 21 (1971), 111—119.

[21] A. Seidenberg, "The Origin of Mathematics," AHES 18 (1978), 301—342.

[22] For specific aspects of the geometry of the Śulbasūtras one should consult, in addition to the books and articles previously cited, those listed in the article on Āpastamba in CESS A1, 50a, as well as R. C. Gupta, "Baudhāyana's Value of $\sqrt{2}$," ME 6 (1972), B 77—79, and R. P. Kulkarni, "The Value of π Known to Śulbasūtrakāras," IJHS 13 (1978), 32—41.

adhyāyas respectively, 1 *khaṇḍa* in each of the remaining six *adhyāyas*); these correspond to three *adhyāyas* in Thibaut's edition:

Thibaut	Prakash and Sharman
adhyāya 1	*adhyāya* 1 = *khaṇḍas* 1–4.
adhyāya 2	*adhyāya* 2 = *khaṇḍas* 5–7.
adhyāya 3	*adhyāyas* 3–10 = *khaṇḍas* 8–21.

The total number of *sūtras* is 519. The work begins with definitions of the measures used in the constructions and the geometrical propositions employed in designing them; there follows a description of the spatial relations in different altars; and finally there come the rules for constructing the *gārhapatyaciti* and *chandaściti* (*khaṇḍa* 7), the *śyenacit* (*khaṇḍas* 8–9), the *vakrapakṣa vyastapuccha* (*khaṇḍas* 10–11), the *kaṅkacit* (*khaṇḍa* 12), the *ajalacit* (*khaṇḍa* 13), the *praügacit* (*khaṇḍa* 14), the *ubhayataḥ praüga* (*khaṇḍa* 15), the *rathacakracit* (*khaṇḍa* 16), the *droṇacit* (*khaṇḍas* 17–18), the *śmaśānacit* (*khaṇḍa* 19), and the *kūrmacit* (*khaṇḍas* 20–21). The Baudhāyana was commented on by Dvārakānātha Yajvan,[23] whose Śulbadīpikā was composed after Āryabhaṭa, and by Veṅkateśvara Dīkṣita, who wrote his Śulbamīmāṃsā in the Vijayanagara kingdom in about 1600.

The Āpastamba, which is divided into six *paṭalas* and twenty-one *adhyāyas* (3 *adhyāyas* in *paṭalas* 1, 3, and 5, 4 in *paṭalas* 2, 4, and 6), presents essentially the same material as does the Baudhāyana, though with fewer variations on the basic forms of the altars, in 223 *sūtras*. It was commented on by Kapardisvāmin,[24] who apparently lived before 1150 (Kapardibhāṣya); by Karavindasvāmin,[25] who has followed Kapardisvāmin (Śulbapradīpikā) and quotes from the Āryabhaṭīya; by Gopāla[26] (Rahasyaprakāśa); and by Sundararāja, the famous Kerala astronomer of the end of the fifteenth century (Sundararājīya).

The first section of the Kātyāyana, which consists of ninety *sūtras*, is divided into six *kaṇḍikās*. It teaches, in language often identical with or similar to the Āpastamba's, the geometrical propositions (including the first detailed instructions for determining the cardinal directions from the shadows cast by a gnomon), the measures employed in constructing the altars, and their spatial relationships. The second section, which consists of more than 40 verses, repeats some of the material given in the *sūtra* section, and adds to it descriptions of the rope, the gnomon, and the expert builder of altars. There are commentaries on the Kātyāyana by Karka,[27] who wrote before 1260/1270 (Karkabhāṣya); by Rāma Vājapeyin, who composed three of them[28] (the Śulbavārttika, a metrical gloss

[23] CESS A 3, 123a.
[24] CESS A 2, 19b.
[25] CESS A 2, 24a.
[26] CESS A 2, 130b.
[27] CESS A 2, 24a.
[28] S. L. Katre, "Three Works by Rāma Vājapeyin Pertaining to Kātyāyana's Śulbasūtra," PAIOC 13 (1946), 72–78.

on the Kātyāyana and on the Karkabhāṣya, in 1434; the Śulbavārttikaṭīkā, a commentary on the preceding; and the Śulbasūtravṛtti, a prose commentary based on the Śulbavārttika) at Naimiṣa in Uttarapradeśa; and by Mahīdhara[29] at Vārāṇasī in 1590 (Śulbasūtravivaraṇa).

Finally, the Mānava, which is divided into seven *khaṇḍas*, describes the rope and the gnomon, the measures, the spatial relations of altars, the sacrificial fees, and the method of constructing the *suparṇaciti*. The closely related Maitrāyaṇīya, which is divided into four *khaṇḍas*, arranges this material in a different fashion. The Mānava was commented on by Śivadāsa at Vārāṇasī, the Maitrāyaṇīya by his younger brother, Śaṅkarabhaṭṭa; the two brothers both quote from Rāma Vājapeyin, and therefore lived after 1450.

[29] CESS A 4.

Chapter II

ASTRONOMY[1]

Many Vedic sacrifices are to be performed at specific times determined by the position of the Sun relative to its northern *(uttarāyana)* or southern *(dakṣiṇāyana)* path, the synodic month and the night within it, or the position of the Moon with respect to the *nakṣatras*. The first attempt in India to describe the motions of the Sun and the Moon relative to the *ayanas*, the *nakṣatras*, and each other was the Jyotiṣavedāṅga composed by Lagadha. He clearly states his purpose (JV Ṛk 36; repeated at the end of Paitāmahasiddhānta 9, 8):

> For the Vedas have come forth for the sake of sacrifice, and sacrifices are established in the orderly succession of times. Therefore, he who knows this *jyautiṣa*, the science of determining times, knows the sacrifices.

This purpose shifted somewhat later on when it was no longer as important to decide when Vedic sacrifices should take place as it was to fix the proper moments *(muhūrta)* for performing the *saṃskāras* and to compute the calendar *(pañcāṅga)* which indicated festivals, auspicious and inauspicious times *(tithis, yogas,* or *karaṇas)*, entries of the Sun into zodiacal signs *(saṅkrāntis)*, eclipses *(grahaṇas)*, and the like. Another motive for the development of astronomy in India, at least after the second century A.D., was the need to compute with reasonable accuracy the positions of the planets for the purpose of casting horoscopes. And a final goal of the astronomers, though only to a slight degree realized, was the application of this science to geographical problems. Such practical aims, of course, must often have been secondary to individuals whose primary motivation was intellectual curiosity.

The history of Indian astronomy can be divided into five main periods, depending in most cases on the foreign origin:

1. Vedic (ca. 1000 B.C.—400 B.C.), in which some of the basic Indian calendaric terms were introduced,[2] but in which only a crude and rudimentary mathematical structure is evident. As there is no astronomical literature as such from this period it shall not be considered further in this book.
2. Babylonian (ca. 400 B.C.—200 A.D.).

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[1] A detailed survey of this field is given in D. Pingree, "History of Mathematical Astronomy in India," DSB, vol. 15, New York 1978, pp. 533—633 (henceforth cited as "History").

[2] "History," pp. 534—536.

3. Greco-Babylonian (ca. 200–400).
4. Greek (ca. 400–1600).
5. Islamic (ca. 1600–1800).

Though the fundamental approach and many of the models and parameters of each period were determined by the foreign sources, the basic traditions of Indian astronomy imposed on these external systems its peculiar stamp, and transformed the science of Mesopotamia, Greece, or Iran into something unique to India.

Babylonian[3]

The literature on astronomy in Sanskrit is headed by the Jyotiṣavedāṅga, which has come down to us in two recensions: that of the Ṛgveda in 36 verses, ascribed to Lagadha (or to Śuci following Lagadha), and that of the Yajurveda in 43 or 45 verses, of which 29 occur also in the Ṛgveda recension.[4] The earlier of these two recensions is clearly the shorter, that of the Ṛgveda, as it alone preserved the original period relation of Lagadha's intercalation cycle:

5 solar years = 1830 sidereal days = 62 synodic months = 1860 *tithis*
(JV, Ṛk 32 = Yajus 5; Ṛk 4 = Yajus 13; Ṛk 18 = Yajus 39; Ṛk 8 = Yajus 9; and Ṛk 12 = Yajus 27).[5]

The Yajus has introduced two verses (28–29) that misinterpret this relation by taking the 366 sidereal days (= 365 civil days) in each year to be themselves civil days.

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[3] "History," pp. 536–538.

[4] The Yajus recension with variants from the Ṛk and the generally unrewarding commentary by Somākara Śeṣanāga was edited by A. WEBER, Über den Vedakalender Namens Jyotisham, Berlin 1862; the text of the Yajus recension along with the non-Yajus verses of the Ṛk recension were edited by G. THIBAUT, "Contributions to the Explanation of the Jyotisha-Vedánga," JAS Bengal 46 (1877), 411–437; the Ṛk recension with a Marāṭhī translation was published by J. B. MOḌAKA of Thana in 1885; both recensions were edited and commented on by BĀRHASPATYA (LĀLA CHOṬELĀL) in the Hindustan Review for 1907 (reprinted Allahabad, 1960) and again, with Somākara's Bhāṣya on the Yajus, by S. DVIVEDIN (Benares, 1908). The Yajus recension was published with his own Sanskrit commentary and an English version by R. SHAMASASTRY (Mysore, 1936).

[5] The fundamental interpretation of the JV is D. PINGREE, "The Mesopotamian Origin of Early Indian Mathematical Astronomy," JHA 4, 1973, 1–12. It has recently been most unconvincingly argued that the two Mesopotamian instruments for measuring time used in this period—the outflowing water-clock *(ghaṭikā)* and the gnomon *(śaṅku)*—were indigenous to India; see S. S. LISHK and S. D. SHARMA, "Season Determination through the Science of Sciatherics in Jaina School of Astronomy," IJHS 12 (1977), 33–44, and "Length of the Day in Jaina Astronomy," Centaurus 22 (1978), 165–176.

The age of Lagadha's work can be fixed from the following considerations. Its language is post-Vedic, and it imitates Piṅgala's Chandaḥsūtra in using the final or first syllables of the names of the *nakṣatras* as their designations;[6] its period relation is copied in the oldest Paitāmahasiddhānta, whose epoch is 11 January 80;[7] and its astronomy reflects that of Mesopotamia in the Achaemenid period. It is likely, therefore, that it was composed not very many years before or after 400 B.C., when the Achaemenids controlled Gandhāra.

Lagadha has retained the Vedic list of twenty-seven *nakṣatras* beginning with Kṛttikā, but treats them not as constellations, but as measurements of arcs on the ecliptic of 13;20° each beginning with the vernal equinox. This adaptation means, of course, that the actual position of the equinoctial and solsticial colures with respect to the fixed stars can not be used for dating the JV. He introduced into Indian astronomy the Mesopotamian concepts of the possibility of describing mathematically the periodicity of celestial motions; their use of linear zig-zag functions to describe periodic deviations from the mean (Ṛk 7 = Yajus 8 and Ṛk 22 = Yajus 40); and their artificial time-unit, a thirtieth of a mean synodic month (named *tithi* in Sanskrit). He gives rules for computing the mean longitudes of the Sun and the Moon in terms of *nakṣatras*, but mentions neither the planets nor the zodiacal signs. Other texts that reflect this level of astronomy are Kauṭilya's Arthaśāstra (2, 20) and the Buddhist Śārdūlakarṇāvadāna (Divyāvadāna 33). The revised system of the Yajus recension is used in the Jaina Sūriyapannatti and Caṃdapannatti and in the verses ascribed to Garga in Somākara's Bhāṣya.

Greco-Babylonian[8]

Planetary astronomy was introduced into India from Greece in conjunction with astrology as it was essential to possess some means of determining planetary positions in order to be able to cast horoscopes. The form of planetary astronomy originally transmitted represented Greek adaptations of the Babylonian astronomy of the Seleucid period; this was supplemented by other elements of early Greek astronomy, especially elements associated with Hipparchus.[9] Some of the calendaric and other timekeeping conventions of the JV were also adopted by the practitioners of this type of astronomy in India.

Two Sanskrit texts have preserved for us what remains of Greco-Babylonian astronomy in India. Sphujidhvaja (269/70) describes some aspects of it in the last chapter (79) of the Yavanajātaka,[10] a text based in large part on the

[6] WEBER, pp. 5—7.

[7] PS 12.

[8] "History," pp. 538—554.

[9] D. PINGREE, "The Recovery of Early Greek Astronomy from India," JHA 7 (1976), 109—123, esp. 111—115.

[10] D. PINGREE, The Yavanajātaka of Sphujidhvaja, 2 vols., Cambridge, Mass. 1978.

translation of a Greek text from Alexandria made by Yavaneśvara in 149/150; Sphujidhvaja (YJ 79, 3) refers to a *siddhānta* by Vasiṣṭha. Varāhamihira in the sixth century summarized in his Pañcasiddhāntikā[11] a Vasiṣṭhasiddhānta whose epoch is 3 December 499 (PS 2; and, probably, 17, 1–60), a Romakasiddhānta (*siddhānta* of the Romans) of the third or fourth century (PS 1, 9–10 and 15; and 8), and a Pauliśasiddhānta (*siddhānta* of Paulus ?) of the same period (PS 1, 11–13; 3; and 17, 64–80). The last two *siddhāntas* were known to Varāhamihira in recensions produced by Lāṭadeva; his epoch for them was 21 March 505. The original version of the Romakasiddhānta was probably the one used by Bhāskara (629) in his Bhāṣya on A (pp. 183, 186 and 202).

The Babylonian component of the astronomy expounded in these works is especially noticeable in the planetary theory which is based on the well known period relations for the planets, and the divisions of the synodic periods at the Greek-letter phenomena (YJ 79, 35–36, and PS 17), and in the elaborate lunar theory of the Vasiṣṭhasiddhānta (PS 2, 2–6) and the Pauliśasiddhānta (PS 3, 4–9). It would not have been possible to compute planetary positions with only the information in the texts as extant; their original forms were presumably more complete. The Hipparchan elements include the year-length 6,5;14,48 civil days (probably YJ 79, 34), which is combined with the Metonic cycle in the Romakasiddhānta (PS 1, 9–10 and 15); values close to his maximum solar and one of his maximum lunar equations, also in the Romakasiddhānta (PS 8); and the use of analemmata to solve problems in spherical trigonometry in the Pauliśasiddhānta (PS 3). Also from Hipparchus came the concept of the precession and trepidation of the equinoxes,[12] and, most likely, the polar coordinate system for fixing the positions of the fixed stars and the value 3438 for the Radius in tables of Sines.[13] This value of R first appears in India in the early fifth century (Pait. 3, 12); Varāhamihira uses R = 120 (PS 4, 6–15).

The other main topics dealt with in these texts, in so far as we know them, were the computations of lunar (PS 6: Pauliśasiddhānta) and solar (PS 7: Pauliśasiddhānta; and 8: Romakasiddhānta) eclipses. Both seem to reflect Hellenistic astronomy as it was influenced by Mesopotamia, though no extant Greek texts can be pointed to as sources. It is likely that the formulas for solving problems in spherical trigonometry and the analemmata that lie behind them in PS 4 also were originally transmitted to India from the Roman Empire.

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[11] O. Neugebauer and D. Pingree, The Pañcasiddhāntikā of Varāhamihira, 2 vols., Copenhagen 1970–71. See also K. S. Shukla, "The Pañcasiddhāntikā of Varāhamihira (I)," Gaṇita 24 (1973), 59–73, and IJHS 9 (1974), 62–76, and T. S. Kuppana Sastri, "Some Misinterpretations and Omissions by Thibaut and Sudhakara Dvivedin in the Pañcasiddhāntikā of Varāhamihira," VIJ 11 (1973), 107 to 118.

[12] D. Pingree, "Precession and Trepidation in Indian Astronomy before A.D. 1200," JHA 3 (1972), 27–35.

[13] G. J. Toomer, "The Chord Table of Hipparchus and the Early History of Greek Trigonometry," Centaurus 18 (1973), 6–28.

Greek[14]

By the early fifth century when the Brāhmapakṣa began there had been introduced into India a more sophisticated form of Greek astronomy characterized by planetary models comprising the combination of an eccentric deferent with an epicycle (but without Ptolemy's equant or special model for Mercury), or a Peripatetic model with two independent epicycles whose centers are carried by a concentric deferent,[15] or one in which each inequality is accounted for by a concentric circle with an equant.[16] The inequalities in the motions of the Sun and the Moon are computed by means of an eccentric, a concentric deferent with an epicycle (the preferred model), or a concentric circle with an equant; in the earlier part of the Greek period Ptolemy's second lunar inequality was not known, though it was introduced into India from Islamic sources in the tenth century.

As these geometric models of planetary motion based on the idea of the circularity of their orbits were introduced into India, it became necessary to modify the traditional Indian cosmology as expressed in the Purāṇas and other texts. This was done by transforming the disc of Jambūdvīpa into a sphere and Meru into the terrestrial North Pole; along the equator at 90° distance from each other lie Laṅkā on the prime meridian, Romakaviṣaya, Siddhapura, and Yamakoṭi; opposite Meru at the South Pole is Vaḍavāmukha. The axis of the universe passes through Meru and Vaḍavāmukha and the poles of the spheres of the planets and of the *nakṣatras;* the spheres of the planets rotate from West to East at a uniform velocity, driven by bonds of wind, while they and the sphere of the *nakṣatras* rotate diurnally from East to West. The deviations of the planets from their mean motions are caused by demons stationed at their *manda* (accounting for the equation of the center) and *śīghra* (accounting for the equation of the anomaly) *uccas* pulling them towards themselves by cords of wind. The relative distance of each planet's sphere from the center of the system—that is, the center of the earth—can be computed by comparing their sidereal periods since they move equal spatial distances (but unequal angular distances) in equal times. Absolute values for planetary distances depend on the assumption of an arbitrary number of *yojanas* in the orbit of one of them (that of the Moon was normally chosen). In order to retain the Greek order of the planets in which the Sun is further distant from the earth than Venus, the Indians operated with the motion of Venus' (and then, by analogy, Mercury's) *śīghra;* in Ptolemaic terms the *śīghra* for an inferior planet is the sum of its (i.e., the Sun's) mean motion and its anomalistic motion.

In order to compute the mean longitudes of the planets the Indians adapted the Greek idea of a "great year" which begins and ends with a mean planetary

[14] "History," pp. 555—625.

[15] D. Pingree, "On the Greek Origin of the Indian Planetary Model Employing a Double Epicycle," JHA 2 (1971), 80—85.

[16] D. Pingree, "Concentric with Equant," AIHS 24 (1974), 26—29.

conjunction to the already existing theory of the Kalpa.[17] The choice of the subdivisions of the Kalpa (see Table 1) and of the number of rotations of each of the planets within it (see Table 2) are two of the main features that distinguish one *pakṣa* or school of astronomy from another, the others being the geometrical models for planetary motion and their parameters (see Table 3). It was demonstrated by R. Billard that the mean longitudes computed by the two systems of Āryabhaṭa converge in accuracy on about 500, and this led him to suggest that Āryabhaṭa founded Indian astronomy in the form which we have called "Greek" on the basis of his own extraordinarily precise observations.[18] However, the same phenomenon is explained in a way that fits better into the known facts of the history of Indian astronomy: that "Greek" astronomy existed in India before Āryabhaṭa; that the geometrical models solve problems faced by Greeks rather than by Indians, and must have been accompanied by means of computing mean longitudes when they were transmitted to India; and that all of the Indian evidence is against the theory of their being able to make accurate observations. This alternate explanation assumes that two procedures were used.[19] One, utilized by the Brāhmapakṣa, consists of an expansion of Babylonian-type period relations to numbers of rotations of the planets in a Kalpa by assuming a fixed time between the beginning of the Kalpa and the beginning of the current Kaliyuga on 18 February −3101, and a close proximity to a mean conjunction of the planets on the latter date. This problem results in a series of indeterminate equations that can be solved by the *kuṭṭaka*. Āryabhaṭa could have arrived at his surprising accuracy by using a reasonably accurate set of Greek astronomical tables to compute the mean longitudes of the planets on 21 March 499, and by assuming a true mean conjunction of the planets 3600 years earlier, on 18 February −3101.

The five main *pakṣas* that developed in India are the Brāhma,[20] the Ārya,[21] the Ārdharātrika,[22] the Saura,[23] and the Gaṇeśa;[24] the Brāhma and the Saura both were revised in the medieval period. There are, as well, some texts which belong to no *pakṣa*,[25] and some derived from Islam.[26] These find their expression in various literary forms, which were classified under three main headings from the seventh century on. *Siddhāntas* are comprehensive treatises deducing mean motions from the beginning of the Kalpa or the current Kaliyuga; *karaṇas* are

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[17] D. Pingree, "Astronomy and Astrology in India and Iran," Isis 54 (1963), 229–246.

[18] R. Billard, L'astronomie indienne, Paris 1971.

[19] D. Pingree in JHA 7 (1976), 116–121.

[20] "History," pp. 555–589.

[21] "History," pp. 590–602.

[22] "History," pp. 602–608.

[23] "History," pp. 608–618.

[24] "History," pp. 624–625.

[25] "History," pp. 618–624.

[26] "History," pp. 625–629, and D. Pingree, "Islamic Astronomy in Sanskrit," JHAS 2 (1978), 315–330.

more concise expositions of astronomy in which the mean longitudes for a time close to the date of composition are given, and the mean longitudes at later times are computed therefrom; and *koṣṭhakas* are sets of astronomical tables, for determining planetary positions or for solving other problems in astronomy. There are as well many specialized works on aspects of astronomy, of which the most important group is on observational instruments *(yantra)*.

Table 1

Brāhma:	
Kalpa	= 4,320,000,000 years
Kalpa	= 14 Manvantaras
	(Manvantara = 71 Mahāyugas = 306,720,000 years)
	+ 15 Sandhis (Sandhi = Kṛtayuga = 1,728,000 years)
Kalpa	= 1000 Mahāyugas or Caturyugas
	(Mahāyuga = 4,320,000 years)
Mahāyuga	= Kṛtayuga (1,728,000 = 432,000 · 4 years)
	+ Tretāyuga (1,296,000 = 432,000 · 3 years)
	+ Dvāparayuga (864,000 = 432,000 · 2 years)
	+ Kaliyuga (432,000 years)
Beginning of Kalpa to beginning of current Kaliyuga:	
	1,972,944,000 = 432,000 · 4567 years
Ārya = Ārdharātrika:	
Kalpa	= 4,354,560,000 years
Kalpa	= 14 Manvantaras
	(Manvantara = 72 Mahāyugas = 311,040,000 years)
Kalpa	= 1008 Mahāyugas (Mahāyuga = 4,320,000 years)
Mahāyuga	= Kṛtayuga (1,080,000 years)
	+ Tretāyuga (1,080,000 years)
	+ Dvāparayuga (1,080,000 years)
	+ Kaliyuga (1,080,000 years)
Saura: same as Brāhma, but with an initial period of non-motion at the beginning of the Kalpa amounting to 17,064,000 years.	

Table 2[1]

Rotations of the planets in a Mahāyuga

	Brāhma	Ārya	Ārdharātrika	Saura	Adjusted Saura
Saturn	146,567.298	146,564	146,564	146,568	146,580
Jupiter	364,226.455	364,224	364,220	364,220	364,212
Mars	2,296,828.522	2,296,824	2,296,824	2,296,832	2,296,832
Venus' śīghra	7,022,389.492	7,022,388	7,022,388	7,022,376	7,022,364
Mercury's śīghra	17,936,998.984	17,937,020	17,937,000	17,937,060	17,937,076
Moon	57,753,300.000	57,753,336	57,753,336	57,753,336	57,753,336
Lunar node	—232,311.168	—232,226	—232,226	—232,238	—232,246

[1] The revised Brāhmapakṣa and the Gaṇeśapakṣa do not express their mean motions in terms of integer numbers of rotations in a Kalpa or a Mahāyuga.

Table 3

A. *Mandoccas* and *pātas*[1]

	Brāhma	Ārya	Ārdharātrika	Saura	Gaṇeśa
Saturn					
ucca	260;55°	236°	240°	236;37°	240° (8 · 30)
pāta	103;12°	100°		100;24°	
Jupiter					
ucca	172;32°	180°	160°	171;18°	180° (6 · 30)
pāta	82;1°	80°		79;41°	
Mars					
ucca	128;24°	118°	110°	130;2°	120° (4 · 30)
pāta	31;54°	40°		40;4°	
Sun					
ucca	77;55°	78°	80°	77;17°	78°
Venus					
ucca	81;15°	90°	80°	79;50°	90° (3 · 30)
pāta	59;47°	60°		59;43°	
Mercury					
ucca	224;54°	210°	220°	220;27°	210° (7 · 30)
pāta	21;11°	20°		20;43°	

[1] These rotate slowly in the Brāhma and Saura *pakṣas;* the parameters given are for 628 and 850 respectively.

B. Maximum Equations[1]

I. *Manda*

	Brāhma	Ārya	Ārdharātrika	Saura	Gaṇeśa
Saturn	4;46,47°	9;32°	9;36,55, ...°	7;40°	9;18°
Jupiter	5;15,35°	5;43°	5;6°	5;6°	5;42°
Mars	11;12,41°	13;7°	11;13°	11;32°	13;0°
Sun	2;10,30°	2;9°	2;14°	2;10,32°	2;10,45°
Venus	1;45,3°	1;26°	2;14°	1;45°	1;30°
Mercury	6;3,33°	3;35°	4;28°	4;28°	3;36°
Moon	5;2,7°	5;1°	4;56°	5;2,48°	5;1,40°

[1] Deviations from these basic parameters occur in some texts of each *pakṣa*.

II. *Śīghra*

	Brāhma	Ārya	Ārdharātrika	Saura	Gaṇeśa
Saturn	5;34,46°	5;44°	6;20°	6;22°	5;42°
Jupiter	10;53,19°	10;53°	11;30°	11;31°	10;48°
Mars	42;37,39°	44;53°	40;30°	40;16°	40;0°
Venus	46;22,54°	53;37°	46;15°	46;24°	46;6°
Mercury	21;31,30°	21;57°	21;30°	21;31°	21;12°

C. Maximum Latitudes

	Brāhma	Ārya = Ārdharātrika = Saura
Saturn	2;26°	2;15°
Jupiter	1;34°	1;15°
Mars	5;38°	4;26°
Venus	8°	7;37°
Mercury	4°	1;36°
Moon	4;30°	4;30°

Siddhāntas

The earliest *siddhānta* that has come down to us is a Paitāmahasiddhānta[27] of the early fifth century. This is preserved because of its incorporation into the Viṣṇudharmottarapurāṇa[28] (2, 166–174), though it also (or at least the astronomical section, chapters 168–174) has been copied as an independent treatise.[29] Its position as the source of the Brāhmapakṣa is made evident by Brahmagupta's dependence on it in composing the first ten chapters (Daśādhyāyī) of the BSS, and was explicitly recognized by Kamalākara (Siddhāntatattvaviveka 1, 62). Its chronological position is fixed by the fact that Sassanian astronomers in about 450 knew one of its characteristic parameters;[30] this makes it more than likely that Pitāmaha is the Svayambhū referred to by Āryabhaṭa (A Gola 50), whose Kalpa-system is a modification of the Brāhmapakṣa's (he even accepts the Brāhma's rotation of the *uccas* and *pātas* [A Daśagītikā 7 and Gola 2] despite the fact that in his system that is unnecessary), whose table of Sines (A Daśagītikā 10 and Gaṇitapāda 12) is derived from the Pait. (3, 12), and who copies various other formulae from the same source.

The Pait. is cast in the form of a lecture by Brahmā to Bhṛgu. Its first two chapters deal with astrology. Chapter three discusses time-measurements, the parameters of the planetary system, Sines and Versines, the declination of the Sun and latitudes of the planets, gnomon-problems, right and oblique ascensions, a star catalogue, the Greek-letter phenomena of the planets, and the calendar; this confused congeries is also indicative of the age of the Pait. as later *siddhāntas* are arranged far more systematically. Chapter four covers the computation of the *ahargaṇa* (number of days lapsed since epoch), the astrological lords of the years, days, and *parvans*, the computation of the mean and true longitudes of the planets and of their latitudes, and the times of the occurrences of the planets' first and second stations. Chapter five deals with the earth's shadow (for lunar eclipses), *saṅkrāntis*, *tithis*, *karaṇas*, *yogas*, and the *vaidhṛta* and *vyatīpāta pātas*. Chapter six covers some problems in spherical trigonometry and their solution by means of analemmata. Chapter seven is devoted to the computation of the ascendant and of the time lapsed since sunrise. Chapter eight presents the method of computing the times and longitudes of the first and last visibilities of the planets and fixed stars. And chapter nine gives rules for computing the illumination of the Moon and longitudinal and latitudinal parallax (for solar eclipses). Several of these rules are incomplete or wrong as presented in the two editions, and only the preliminaries for computing lunar

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[27] CESS A 4.

[28] Bombay, 1912.

[29] Ed. by V. P. Dvivedi in Jyautiṣasiddhāntasaṅgraha, BSS 39, 2, Benares, 1912; trans. by D. Pingree, "The Paitāmahasiddhānta of the Viṣṇudharmottarapurāṇa," Brahmavidyā 31–32 (1967–68), 472–510.

[30] D. Pingree, "The Persian 'Observation' of the Solar Apogee in *ca.* A.D. 450," JNES 24 (1965), 334–336.

and solar eclipses are given. One suspects that the original Pait. was a more competent work than what we now possess of it.

Āryabhaṭa[31] was 23 years old in 3600 Kali = A.D. 499 (A Kālakriyā 10) and wrote his Āryabhaṭīya[32] at Kusumapura (A Gaṇitapāda 1), which is identified by Bhāskara in his commentary on this verse with Pāṭaliputra (p. 45). The same Bhāskara, in a series of examples relating to the *kuṭṭaka*, refers to the Aśmakasya *gaṇita* (p. 138), or Aśmakīya (pp. 140, 146, 147, and 148), or Aśmaka as an authority on the subject, and he applies to the Āryabhaṭīya the epithet Aśmaka (e.g., in MB 1, 3). Scholars, beginning at least with Nīlakaṇṭha (on A Gaṇitapāda 1), have contended on this basis that Āryabhaṭa was born in the Aśmaka country between the Godāvarī and the Narmadā; but the epithet may only reflect Bhāskara's own origin and training in Aśmaka.

The Āryabhaṭīya, which is the basic text of the Āryapakṣa, is not, strictly speaking, a *siddhānta* since it combines, in extreme conciseness, the fundamentals of both astronomy and mathematics. It is divided into four *pādas*. The Daśagītikā gives the planetary parameters, the divisions of the Kalpa, and a table of the first order differences of the Sines; at one point Āryabhaṭa refers to the diurnal rotation as a rotation of the earth (A Daśagītikā 3; see also Golapāda 9–10) but elsewhere (A Golapāda 16) he mentions the mathematically equivalent theory of the rotation of the fixed stars *(bhagola)*. The theory of the diurnal rotation of the earth was fiercely attacked by many later Indian astronomers, beginning with Varāhamihira (PS 13, 6–7). The Gaṇitapāda, on mathematics, will be briefly discussed in chapter III. The Kālakriyāpāda defines time units, describes two geometrical models of planetary motion (eccentric with epicycle and concentric with two epicycles), and gives rules for computing the true longitudes of the planets. Finally, the Golapāda expounds Āryabhaṭa's cosmology and geography, explains the apparent motions of the heavenly bodies, and gives solutions for problems in spherical trigonometry and rules for computing eclipses. The Āryapakṣa which evolved from the A was for most of its history popular mainly in South India, though the earliest extant commentaries were composed in Gujarāt—the Āryabhaṭīyabhāṣya of Bhāskara[33] at

[31] CESS A 1, 50b–53b; A 2, 15b; A 3, 16b; and A 4.

[32] Edited with the Bhaṭadīpakā of Parameśvara by H. Kern, Leiden 1875, reprinted (with a Hindi translation by Udaya Narayana Singh), Madhurapur, Etawah, 1906, and Osnabrück 1973; with the Bhāṣya of Nīlakaṇṭha (omitting the Daśagītikā) by K. Sambasiva Sastri (2 vols., TSS 101 and 110) and S. K. Pillai (TSS 185), Trivandrum 1930–1957; with Sanskrit and Hindi commentaries by B. Mishra, Patna [1966]; with an English translation by K. S. Shukla and K. V. Sarma, New Delhi 1976; with the commentaries of Bhāskara (to Golapāda 6) and Someśvara (Golapāda 6–50) by K. S. Shukla, New Delhi 1976; and with the commentary of Sūryadeva Yajvan by K. V. Sarma, New Delhi 1976. The Gaṇitapāda was published with a German translation and commentary by K. Elfering, Die Mathematik des Āryabhaṭa I, München 1975. There are English translations of the whole work by P. C. Sengupta, JDL/UC 16 (1927), art. 6, and by W. E. Clark, Chicago 1930.

[33] CESS A 4.

Valabhī in 629 and that of Someśvara in the eleventh or twelfth century; equally attesting to its popularity in Western India in the eighth and early ninth centuries is its use by Arabic astronomers of the period, who call Āryabhaṭa Arjabhar.[34] Al-Bīrūnī, however, while he possessed a copy of the A in the Panjāb in the 1020's, was confused about its identity.[35] The later Indian commentators on the A, almost all of its manuscripts, and most of the texts following the Āryapakṣa[36] come from South India. The Sanskrit commentaries in addition to those named above were composed by Sūryadeva Yajvan, who was born in 1191, at Gaṅgāpura in Cola country; by Parameśvara[37] in about 1450 at Aśvatthagrāma in Kerala; by Yallaya at Skandasomeśvara in Āndhrapradeśa in 1480; by Nīlakaṇṭha[38] in Kerala shortly after 1501; by Raghunātha Rāja at Ahobila in Āndhrapradeśa in 1597; by Bhūtiviṣṇu,[39] probably near Kāñcī in Tamilnadu; and by Ghaṭīgopa[40] in Kerala in about 1800. There are also commentaries in Telugu and Malayālam and a translation into Marāṭhī.

Āryabhaṭa wrote a second work that formed the basis of the Ārdharātrikapakṣa, apparently entitled Āryabhaṭasiddhānta. This is now lost, though a number of astronomers have mentioned its views, and some commentators—especially on the Sūryasiddhānta—have quoted its verses.[41] Especially prevalent in these quotations are verses describing Āryabhaṭa's simple and crude observational instruments (e.g., by Mallikārjuna Sūri[42] and by Tammayajvan[43]) and his clepsydras (by Tammayajvan and by Rāmakṛṣṇa). The first treatise to follow the Ārdharātrikapakṣa of the Āryabhaṭasiddhānta was a revised version of the Sūryasiddhānta. This was composed by a pupil of Āryabhaṭa named Lāṭadeva[44] according to the information available to al-Bīrūnī; and there is no good reason to doubt this attribution. As summarized by Varāhamihira in the PS it is a *karaṇa* rather than a *siddhānta;* its epoch is midnight 20/21 March 505. It is nuclear whether this form is that of Lāṭadeva's original, or was imposed on it by Varāhamihira.

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[34] D. PINGREE, "The Greek Influence on Early Islamic Mathematical Astronomy," JAOS 93 (1973), 32—43, esp. 37—38.

[35] D. PINGREE, "Al-Bīrūnī's Knowledge of Sanskrit Astronomical Texts," The Scholar and the Saint, New York 1975, pp. 67—81, esp. 68—69.

[36] K. V. SARMA, "Tradition of Āryabhaṭīya in Kerala: Revision of Planetary Parameters," IJHS 12 (1977), 194—199.

[37] CESS A 4.

[38] CESS A 3, 175b—177b, and A 4.

[39] CESS A 4.

[40] CESS A 2, 147a—147b, and A 4.

[41] See especially K. S. SHUKLA, "Āryabhaṭa I's Astronomy with Midnight Day-reckoning," Gaṇita 18 (1967), 83—105, and "Glimpses from the Āryabhaṭasiddhānta," IJHS 12 (1977), 181—186.

[42] CESS A 4.

[43] CESS A 3, 85a—86a.

[44] PS ed. NEUGEBAUER—PINGREE, vol. 1, pp. 12—15; A with the commentary of Bhāskara ed. SHUKLA, pp. lxi—lxiv.

The earliest extant *siddhāntas* to adhere to something approaching the classical form belong to the Āryapakṣa. They were composed by that Bhāskara who commented on the A at Valabhī in 629; of these the Mahābhāskarīya[45] was written before the Āryabhaṭīyabhāṣya which quotes from it under the title Karmanibandha (pp. 33, 40, 131, 179, 203, 204, 205, and 225–226), while the Laghubhāskarīya[46] summarizes the MB, and probably postdates the Āryabhaṭīyabhāṣya (and the BSS).

An arrangement less rigid than that of the classical *siddhānta* is evident in the contents of the MB's eight chapters:

1. *ahargaṇa;* mean longitudes; planetary *kuṭṭaka.*
2. *deśāntara* correction.
3. spherical trigonometry; catalogue of stars.
4. planetary equations (including the model involving a concentric with equant); *tithis, karaṇas, nakṣatras, pātas,* and *yogas.*
5. solar and lunar eclipses.
6. first visibility and illumination of the Moon; first and last visibilities of the planets; planetary conjunctions.
7. parameters of the Āryapakṣa and of the Ārdharātrikapakṣa.
8. examples.

The arrangement of the eight chapters of the LB, which is probably influenced by that of the Daśādhyāyī of the BSS, represents the first stage of the fully developed form:

1. *ahargaṇa;* mean longitudes; *deśāntara* correction *(madhyama).*
2. planetary equations; *nakṣatras, tithis, karaṇas,* and *pātas (spaṣṭa).*
3. spherical trigonometry *(tripraśna).*
4. lunar eclipses *(candragrahaṇa).*
5. solar eclipses *(sūryagrahaṇa).*
6. first visibility and illumination of the Moon *(śṛṅgonnati).*
7. first and last visibilities and conjunctions of the planets (*udayāsta* and *grahayuti*).
8. catalogue of stars; conjunctions of planets with stars *(bhagrahayuti).*

Both of these *siddhāntas* were, like most Āryapakṣa works, popular only in South India; it is there that most of their manuscripts were copied, and their commentaries written. These commentaries include that composed by Govin-

[45] Edited with the commentary, Karmadīpikā, of Parameśvara by B. D. Apate, ASS 126, Poona 1945; with the Bhāṣya of Govindasvāmin and the super-commentary, Siddhāntadīpikā, of Parameśvara by T. S. Kuppanna Sastri, Madras GOS 130, Madras 1957; and with an English translation and commentary by K. S. Shukla, Lucknow 1960.

[46] Edited with the commentary, Pārameśvara, of Parameśvara by B. D. Apate, ASS 128, Poona 1946; with the Vivaraṇa of Śaṅkaranārāyaṇa by S. Venkatasubramonia Iyer and S. Kochukanju Asari, TSS 162, Trivandrum 1949; and with an English translation and commentary by K. S. Shukla, Lucknow 1963.

dasvāmin[47] (ca. 800—850) in Kerala on the MB, that written by his pupil, Śaṅkaranārāyaṇa, at Kollapurī, Kerala, in 869 on the LB, that composed by Udayadivākara[48] in 1073 on the LB, and those composed by Parameśvara (ca. 1380—1460) in 1408 on the LB and after 1443 on the MB; Parameśvara also wrote after 1432 a super-commentary on the Mahābhāskarīyabhāṣya of Govindasvāmin.

Bhāskara's contemporary rival as an astronomer was Brahmagupta,[49] who was born in 598 and completed his Brāhmasphuṭasiddhānta[50] in 628 at Bhillamāla in Rājasthāna during the reign of the Cāpa (Cāvoṭaka) monarch Vyāghramukha. The BSS, which belongs to the Brāhmapakṣa, was enormously influential on later Indian astronomy as well as on Islamic[51] and Western European.[52] It consists of twenty-four chapters, to which a twenty-fifth—a *karaṇa*—is appended in many manuscripts. These begin with a Daśādhyāyī (chapters 1—10), which summarizes and expands the teachings of the Pait. The relation to (and possible influence on) the LB will be clear from Table 4. This is followed by a chapter (11) in which Brahmagupta criticizes his predecessors and praises the Brāhmapakṣa *(tantraparīkṣā)* and another (12) on mathematics *(gaṇita)*. Subject to the *tantraparīkṣā's* animadversions are Āryabhaṭa, the Jainas, Pradyumna, Lāṭadeva, Varāhamihira, Vijayanandin, Viṣṇucandra's Vasiṣṭhasiddhānta, Śrīṣeṇa's Romakasiddhānta, and Siṃha. Additional information concerning those of these authors whose works are lost can be found in the PS, in the Āryabhaṭīyabhāṣya of Bhāskara, and in several later commentaries (e.g., those of Bhaṭṭotpala on the Bṛhatsaṃhitā and of Pṛthūdakasvāmin on the BSS). The next five chapters of the BSS contain additions and corrections to the Daśādhyāyī: chapter thirteen to chapter one, fourteen to two, fifteen to three, sixteen to four and five, and seventeen to seven. Brahmagupta followed this practice of providing supplementary chapters *(uttara)* in

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[47] CESS A 2, 143b—144a, and A 3, 35b.

[48] CESS A 1, 56b—57a.

[49] CESS A 4.

[50] Edited with his own Sanskrit *ṭīkā* by S. Dvivedin, Benares 1902, and with his own Sanskrit and Hindī *ṭīkās* and excerpts from those of Pṛthūdakasvāmin and Dvivedin by R. Sarman, 4 vols., New Delhi 1966. A new critical edition with the commentary of Pṛthūdakasvāmin, an English translation, and a commentary is being prepared by D. Pingree.

[51] Based on it was a Mahāsiddhānta which was translated into Arabic as Al-Zīj al-Sindhind al-kabīr in 771 or 773 by Muḥammad ibn Ibrāhīm al-Fazārī; see D. Pingree, "The fragments of the Works of al-Fazārī," JNES 29 (1970), 103—123. This tradition was also followed by al-Fazārī's contemporary, Ya'qūb ibn Ṭāriq; see D. Pingree, "The Fragments of the Works of Ya'qūb ibn Ṭāriq," JNES 27 (1968), 97—125. See also D. Pingree, The Thousands of Abū Ma'shar, London 1968.

[52] Concerning the relation of the Sindhind tradition—particularly in the form of the Latin version of al-Khwārizmī's Al-Zīj al-Sindhind and its commentaries—to the BSS and other Sanskrit works see D. Pingree, "The Indian and Pseudo-Indian Passages in Greek and Latin Astronomical and Astrological Texts," Viator 7 (1976), 141—195, esp. 151—169.

his Kh also. The last seven chapters of the BSS are more heterogeneous: eighteen is on the *kuṭṭaka*, nineteen on gnomon problems *(śaṅku)*, twenty on prosody *(chandas)*, twenty-one on cosmology *(gola)*, twenty-two on instruments *(yantra)*, twenty-three on measurements *(māna)*, and twenty-four on the contents of the BSS and on its author *(saṃjñā)*. The BSS was particularly popular in North and West India; the scholar who brought its derivative, the Mahāsiddhānta, to Baghdād in 771 or 773 came from Sind, and the two commentaries known to have been written on it were composed in the North. Balabhadra[53] wrote his at Kānyakubja, probably under Yaśovarman (ca. 725–750); it is now lost except for fragments preserved by Pṛthūdakasvāmin, Bhaṭṭotpala, and al-Bīrūnī. Pṛthūdakasvāmin[54] wrote his monumental Vāsanābhāṣya on the BSS at Sthāneśvara (Sthāṇvīśvara) in Kurukṣetra in the 860's; the commentary on chapters sixteen to twenty, on most of twenty-two, and on twenty-three and twenty-four is lost.

Earlier another astronomer had apparently lived at Sthāneśvara, where, in the eighth century, someone wrote a new Pauliśasiddhānta.[55] This astronomer, while accepting the planetary parameters of the Ārdharātrikapakṣa and the main division of the Kalpa according to the Āryapakṣa, compromised with *smṛti* (and the Brāhmapakṣa) to the extent of accepting the traditional division of a Mahāyuga. In order to achieve a mean conjunction at the beginning of the current Kaliyuga (which he placed 3,888,000 years after the beginning of the current Mahāyuga), he delayed the beginning of celestial motion 648,000 years so that there would remain 3,240,000 years (three of Āryabhaṭa's *yugas*) before the beginning of the current Kaliyuga. The Pauliśasiddhānta is not extant in its entirety, but many fragments remain in the works of Pṛthūdakasvāmin, Bhaṭṭotpala, al-Bīrūnī, and Āmarāja.[56]

Probably also in the eighth century, though perhaps in the early ninth, Lalla composed his Śiṣyadhīvṛddhidatantra[57] following the Āryapakṣa, but with *bījas* for periods of 250 years subsequent to 498 (the numerators of some of these *bījas* are borrowed from Haridatta, who wrote in 683). Lalla may have lived in Daśapura in Mālava, which he mentions (SDV 2, 9, 10). His approximate date is indicated by his initial *bīja*-period, which ends in 748; by his sharing with the Pauliśasiddhānta and the Sūryasiddhānta the Brāhmapakṣa's divisions of a Mahāyuga while retaining Āryabhaṭa's parameters; and by the new organization of the *siddhānta* that he introduced and that was imitated by Vaṭeśvara, who wrote his VS in 904, and, in part, by Śrīpati[58] when he wrote his SŚŚ toward the middle of the eleventh century. This new organization of the *siddhānta* retained essentially the contents of the BSS's Daśādhyāyī

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[53] CESS A4.
[54] CESS A4.
[55] CESS A4.
[56] D. Pingree, "The Later Pauliśasiddhānta," Centaurus 14 (1969), 172–241.
[57] Edited by S. Dvivedin, Benares 1886.
[58] Śrīpati also modelled his Jyotiṣaratnamālā on Lalla's Jyotiṣaratnakośa.

in a first section on computation *(grahagaṇita)*, while gathering theoretical and cosmological material in a second section *(gola)*. The ŚDV was commented on by Bhāskara[59] (b. 1114) and by Mallikārjuna Sūri[60]—probably he who commented on the Sūryasiddhānta in 1178 in Sanskrit, and previously in Telugu. Thus Lalla's work, as is to be expected of one belonging to the Āryapakṣa, was popular in the South; but the presence of manuscripts in Western India and the references to Lalla in, for instance, Āmarāja's commentary on the Kh, show that it was also studied in Gujarāt and Rājasthāna.

The Saurapakṣa was initiated in about 800 by the unknown author of the "modern" Sūryasiddhānta,[61] who has modified many of the planetary parameters of the Ārdharātrikapakṣa (and thereby of Lāṭadeva's Sūryasiddhānta) while retaining others along with the midnight epoch, and who has taken over from the Brāhmapakṣa the traditional divisions of both the Kalpa and the Mahāyuga, but delayed the beginning of the motions of the planets by 17,064,000 years so that the rotations of each within the remainder of the Kalpa are divisible by four. Other elements in the SS indicate its author's knowledge of Brahmagupta's BSS. The popularity of the work was enormous in all parts of India, but especially in the South and Northeast. Virtually every commentator, however, has rearranged the text, adding and subtracting verses ad libitum; the manuscript traditions of these many recensions, especially the earlier ones, will have to be fully investigated before a clear idea of the exact contents of the original can emerge. The most important of the extant Sanskrit commentators are: Mallikārjuna Sūri,[62] who wrote a commentary in Telugu before composing his Sanskrit Sūryasiddhāntaṭīkā in 1178; Caṇḍeśvara,[63] a Maithila Brāhmaṇa whose Sūryasiddhāntabhāṣya was written in 1185; Madanapāla,[64] a Mahārājādhirāja of the Ṭāka family, who wrote his

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[59] CESS A 4.

[60] CESS A 4.

[61] Edited with the commentary of Raṅganātha by F. HALL and BĀPŪ DEVA ŚĀSTRIN, BI 25, Calcutta 1859, repr. Amsterdam [1974]; edited with the same commentary by JĪVĀNANDA VIDYĀSĀGARA, 2nd ed., Calcutta 1891; edited with a Hindī translation by UDAYA NARAIN SINGH, Biddoopur, Meerut, 1903; edited with his own commentary, Sudhāvarṣiṇī, by SUDHĀKARA DVIVEDIN, BI 173, Calcutta 1911, 2nd ed. Calcutta 1925; edited with his own *bhāṣya*, Tattvāmṛta, by KAPILEŚVARA SĀSTRIN, KSS 144, Banārasa 1936; edited with his own Malayālam commentary by PULIYOOR PURUSHOTTAMAN NAMPUTIRI, Trivandram 1950; edited with the commentary of Raṅganātha and a Hindī translation by B. P. MISRA, Bombay 1956; and edited with the commentary of Parameśvara by K. S. SHUKLA, Lucknow 1957. The *madhyama* was edited with his own *ṭīkā*, Sudhādhavalā, by UMĀDATTA JOŚĪ, Hadiyāvāda [ND]. The Sūryasiddhānta was translated into English by E. BURGESS with the assistance of W. D. WHITNEY, JAOS 6, 2 (1860), 141–498, reprinted New Haven 1860 and Calcutta 1935, and by BĀPŪ DEVA ŚĀSTRIN, BI 32, Calcutta 1861, reprinted Amsterdam [1974].

[62] CESS A 4.

[63] CESS A 3, 40b—41a.

[64] CESS A 4.

Vāsanārṇava between 1375 and 1400; Parameśvara,[65] who composed his Sūryasiddhāntavivaraṇa in Kerala in 1432; Yallaya, who wrote his Kalpavallī in Āndhrapradeśa in 1472; Rāmakṛṣṇa Ārādhya, whose Subodhinī was also composed in 1472; Bhūdhara,[66] who wrote his Sūryasiddhāntavivaraṇa at Kāmpilya in 1572; Tamma Yajvan,[67] who composed his Kāmadogdhrī at Paragīpurī in 1599; Raṅganātha, whose Gūḍhārthaprākaśaka was completed in Kāśī in 1603; Nṛsiṃha,[68] who wrote his immense Saurabhāṣya in the same city in 1611; Viśvanātha, also of Kāśī, who composed his Gahanārthaprakāśa in about 1628; Kamalākara,[69] another astronomer of Kāśī, whose Sauravāsanā on SS 1–10 was written after 1658; and Dādābhāī,[70] a Cittapāvana Brāhmaṇa, who composed his Kiraṇāvalī in 1719. The dates of three other commentators, all of whom lived in South India, are unknown; they are Kāmābhaṭṭa[71] (Sūryasiddhāntaṭīkā), Cola Vipaścit[72] (Gaṇakopakāriṇī), and Bhūtiviṣṇu[73] (Gurukaṭākṣā).

A *siddhānta* in which the influence of both the Āryapakṣa and the Saurapakṣa as well as that of Brahmagupta's BSS are apparent is the Vaṭeśvarasiddhānta[74] composed by Vaṭeśvara at Ānandapura in Gujarāt in 904; the arrangement of the chapters follows that of Lalla's ŚDV. One of the more interesting sections is that (VS 1, 1, 10) in which Vaṭeśvara criticizes Brahmagupta as Brahmagupta had criticized his predecessors, and especially Āryabhaṭa (BSS 11).

In about 950–1000 a second Āryabhaṭa[75] wrote a Mahāsiddhānta[76] in large part based on the Brāhmapakṣa, but beginning the planets' rotations 3,024,000 years after the beginning of the Kalpa in the fashion of the Saurapakṣa and substituting a new set of planetary parameters. He also reports another set of new parameters which he found in a treatise ascribed to Parāśara (MS 1, 2). And, while following Lalla in dividing his work into a *grahagaṇita* and a *gola*

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[65] CESS A 4.
[66] CESS A 4.
[67] CESS A 3, 85a–86a.
[68] CESS A 3, 204a–205a.
[69] CESS A 2, 23a.
[70] CESS A 3, 97a–97b.
[71] CESS A 2, 31b.
[72] CESS A 3, 52b–53a.
[73] CESS A 4; a fragment was edited by K. M. K. Sarma, "The Sūryasiddhāntavyākhyā of Bhūtiviṣṇu," Brahmavidyā 5 (1941), 77–83.
[74] *Adhikāras* 1–3 are edited in an unsatisfactory manner by R. S. Sharma and M. Mishra, New Delhi 1962; see also T. S. Kuppanna Shastri, "The System of the Vaṭeśvara Siddhānta," IJHS 4 (1969), 135–143, and K. S. Shukla, "Hindu Astronomer Vaṭeśvara and His Works," Gaṇita 23 (1972), 65–74.
[75] CESS A 1, 53b–54a; A 2, 15b–16a; and A 4.
[76] Edited with his own Sanskrit commentary by Sudhākara Dvivedin, BSS 36, Benares 1910; the *grahagaṇita* was edited with an English translation by S. R. Sarma, 2 vols., Marburg 1966.

section, he follows Brahmagupta's BSS in including chapters on arithmetic and geometry (2, 2 = 15) and on the *kuṭṭaka* (2, 5 = 18) in his *siddhānta*.

Śrīpati, who wrote various works at Rohiṇīkhaṇḍa (about 150 miles south of Ujjayinī) between 1039 and 1056, followed the Brāhmapakṣa when he composed the Siddhāntaśekhara,[77] though he adds the *bījas* to the planetary mean motions that characterize the later history of this school. He also adds to Brahmagupta's astronomy rules for computing the second component *(udayāntara)* of the equation of time (SŚŚ 3, 46) and the evection of the Moon *(sphuṭacaraphala)* (SŚŚ 11, 2–4); the latter rule, which has ultimately an Islamic Ptolemaic origin, had previously been given by Muñjāla. Śrīpati arranged the twenty chapters of the SŚŚ in much the same order as Lalla's ŚDV, though without the latter's division into two sections and with the addition of two chapters (13 and 14) on arithmetic and geometry *(vyaktagaṇita)* and on algebra *(avyaktagaṇita)* respectively. The commentary, Gaṇitabhūṣaṇa, composed by Makkibhaṭṭa[78] in 1377, is preserved only up to 4, 75.

But the most notable *siddhānta* produced in India is the Siddhāntaśiromaṇi[79]

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[77] Edited with the commentary on 1—4 of Makkibhaṭṭa and with his own commentary on 5—20 by Babuāji Miśra, 2 vols., Calcutta 1932—1947.

[78] CESS A 4.

[79] The *gaṇitādhyāya* with Bhāskara's own Mitākṣarā was edited by L. Wilkinson, Calcutta 1842, reprinted Calcutta 1855; the *golādhyāya* with the Mitākṣarā by L. Wilkinson, Calcutta 1842, reprinted Calcutta 1856; edited with the Mitākṣarā by Bāpūdeva Śāstrin, Benares 1866, revised ed. by Candradeva, Benares 1891, revised ed. by Gaṇapatideva Śāstrin, KSS 72, Banarasa 1929; the *golādhyāya* with the Mitākṣarā edited by Jīvānanda Vidyāsāgara, Calcutta 1880, 2nd ed. Calcutta 1899; the *gaṇitādhyāya* with the Mitākṣarā edited by Jīvānanda Vidyāsāgara, Calcutta 1881, revised ed. by Āśubodha Vidyābhūṣaṇa and Nityabodha Vidyāratna, Kalikātā 1915; the *golādhyāya* with the Mitākṣarā and a Bengālī translation edited by Rasikamohana Chaṭṭopādhyāya, Calcutta 1887; the *golādhyāya* with the Mitākṣarā and a Bengālī translation published in Aruṇodaya 1 (1890), pt. 6; the *golādhyāya* published in Bṛhaspati 1 (1896/97); edited with the Mitākṣarā and a Hindī translation by Udai Narain Singh, Bombay 1905; *adhyāyas* 1—8 of the *golādhyāya* with Marāṭhī translation and commentary edited by V. P. Khānāpurkar, Mumbaī 1911; the *golādhyāya* with the Mitākṣarā and a Hindī commentary edited by Girijāprasāda Dvivedin, Lucknow 1911, reprinted Ahmadabad 1936; the *gaṇitādhyāya* with Marāṭhī translation and commentary edited by V. P. Khānāpurkar, Puṇem 1913; *adhyāya* 1 of the *gaṇitādhyāya* with the Mitākṣarā and the commentaries of Nṛsiṃha and Munīśvara edited by Muralīdhara Jhā, Benares 1917; the *golādhyāya* with the Mitākṣarā and a Bengālī translation edited by Rādhāvallabha, Calcutta 1921; the *gaṇitādhyāya* with the Mitākṣarā and the commentary of Gaṇeśa edited by Dattātreya Āpaṭe, ASS 110, 2 vols., Poona 1939—41; the *golādhyāya* with the Mitākṣarā and the commentary of Munīśvara edited by Dattātreya Āpaṭe, ASS 122, 2 vols., Poona 1943—52; *adhyāyas* 1—2 of the *gaṇitādhyāya* with the Mitākṣarā edited by Muralīdhara Ṭhakkura, KSS 149, Banārasa 1950; and the *gaṇitādhyāya* with the Mitākṣarā and the commentary of Munīśvara (the latter not on adhyāya 1) edited by Kedāradatta Jośī, 3 vols., Vārāṇasī 1961—64. The *gaṇitādhyāya* was translated into Latin by E. Roer, JAS Bengal 13 (1844), 53—66; the *golādhyāya* was translated into English by L. Wilkinson, revised by Bāpūdeva Śāstrin, BI 32, Calcutta 1861.

written by Bhāskara[80] at Vijjaḍaviḍa (?) probably in his native Sahyādri north of Devagiri in 1150. Modelled in form on Lalla's ŚDV (though with the addition of a chapter on the trigonometrical functions, *jyotpatti* and of another describing the seasons) the SŚB is the foremost text of the Brāhmapakṣa after the BSS. Bhāskara changes a few parameters minutely, repeats some of the improvements introduced by earlier astronomy such as the equation of time, and presents for the first time the formula for finding Sin $(\alpha + \beta)$,[81] but the most impressive quality of the SŚB is its comprehensiveness. Commentaries on the SŚB were composed by, among others, Bhāskara himself (Mitākṣarā); by Lakṣmīdāsa in 1501 (Gaṇitatattvacintāmaṇi); by Gaṇeśa[82] at Nandipura in Gujarāt in the early seventeenth century (Śiromaṇiprakāśa); by Nṛsiṃha[83] at Kāśī in 1621 (Vāsanāvārttika) and by Munīśvara[84] at Kāśī before 1638 (Marīci).

For approximately 350 years after the composition of the SŚB no important *siddhānta* was written; the learning of astronomers was rather concentrated in commentaries, their ingenuity in *koṣṭhakas*. It was, however, probably during this period that a group of minor *siddhāntas* belonging to the Saurapakṣa, but attributed to deities or sages, were written. These are the Somasiddhānta,[85] on which a commentary, Gūḍhārthadīpikā, was composed by Nṛsiṃha[86] at Koṇḍavīḍu in Āndhrapradeśa in about 1400; a Vasiṣṭhasiddhānta[87] which claims to be based on that of Viṣṇucandra; a Vṛddhavasiṣṭhasiddhānta,[88] which is influenced by the Brāhmapakṣa in its planetary equations; and the Brahmasiddhānta[89] alleged to be part of a Śākalyasaṃhitā.

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[80] CESS A 4.

[81] R. C. Gupta, "Addition and Subtraction Theorems for the Sine and Cosine in Medieval India," IJHS 9 (1974), 164—177.

[82] CESS A 2, 106b—107a.

[83] CESS A 3, 205a—206a.

[84] CESS A 4.

[85] Edited V. P. Dvivedin, BSS 39, 1, Benares 1912, pp. 1—36.

[86] CESS A 3, 201a.

[87] Edited V. P. Dvivedin, Benares 1907.

[88] Edited V. P. Dvivedin, BSS 39, 2, Benares 1912, pp. 25—78.

[89] Edited V. P. Dvivedin, BSS 39, 1, Benares 1912, pt. 2. See CESS A 4.

Table 4

BSS	ŚDV
	I grahagaṇita
1. madhyama	1. madhyama
2. spaṣṭa	2. spaṣṭa
3. tripraśna	3. tripraśna
4. candragrahaṇa	4. candragrahaṇa
5. sūryagrahaṇa	5. sūryagrahaṇa
6. udayāsta	6. parvasambhava
7. candraśṛṅgonnati	7. grahodayāsta
8. candracchāyā	8. candracchāyā
9. grahayuti	9. candraśṛṅgonnati
10. bhagrahayuti	10. grahayuti
	11. bhagrahayuti
11. tantraparīkṣā	12. mahāpāta
12. gaṇita	13. uttara
13. madhyamagatyuttara	II gola
14. sphuṭagatyuttara	1. chedyaka
15. tripraśnottara	2. golabandha[1]
16. grahaṇottara	3. madhyagativāsanā
17. śṛṅgonnatyuttara	4. bhūgola
	5. grahabhramasaṃsthā
18. kuṭṭaka	6. bhuvanakośa
19. śaṅkucchāyādijñāna	7. mithyājñāna
20. chandaścittyuttara	8. yantra
21. gola	9. praśna
22. yantra	
23. māna	
24. saṃjñā	

[1] Divided into khagolabandha, bhagolabandha, grahagolabandha, and sāmānyagolabandha.

(Table 4 cont.)

SS[1]	VS	MS
	I grahaganita	I grahaganita
1. madhyama	1. madhyagati	1. madhyama
2. spaṣṭa	2. sphuṭagati	2. pārāśaramata
3. tripraśna	3. tripraśna	3. spaṣṭa
4. candragrahaṇa	4. candragrahaṇa	4. tripraśna
5. sūryagrahaṇa	5. ravigrahaṇa	5. candragrahaṇa
6. chedyaka	6. udayāstamaya	6. sūryagrahaṇa
7. grahayuti	7. śṛṅgonnati	7. śṛṅgonnati
8. bhagrahayuti	8. samāgama	8. chedyaka
9. udayāsta		9. udayāsta
10. candraśṛṅgonnati	II gola	10. grahacchāyā
11. pāta	1. golapraśaṃsā	11. grahayuti
12. bhūgola	2. golabandha	12. bhagrahayuti
13. jyautiṣopaniṣad	3. chedyaka[2]	13. pāta
14. māna		
		II gola
		14. praśna
		15. pāṭī
		16. bhuvanakośa
		17. praśnottara
		18. kuṭṭaka

[1] *Adhikāras* 1—11 are sometimes regarded as the *pūrvārdha*, 12—14 as the *aparārdha*.
[2] What follows this is unclear.

(Table 4 cont.)

SŚŚ	SŚB[1]	SSJ
	I grahaganita	I grahaganita
1. sādhana	1. madhyama	1. madhyama
2. madhyama	2. spaṣṭa	2. spaṣṭīkaraṇa
3. sphuṭagati	3. tripraśna	3. tripraśna
4. tripraśna	4. parvasambhava	4. parvasambhūti
5. candragrahaṇa	5. candragrahaṇa	5. candragrahaṇa
6. sūryagrahaṇa	6. sūryagrahaṇa	6. sūryagrahaṇa
7. parvasambhava	7. grahacchāyā	7. grahodayāsta
8. pāta	8. grahodayāsta	8. nakṣatracchāyā
9. udayāsta	9. śṛṅgonnati	9. śṛṅgonnati
10. candra	10. grahayuti	10. grahayoga

SŚŚ	SŚB[1]	SSJ
11. grahayuddha	11. bhagrahayuti	11. bhadhruva
12. bhagrahayoga	12. pāta	12. pāta
13. vyaktagaṇita		
14. avyaktagaṇita		
	II gola	II gola
15. golavāsanā	1. golapraśaṃsā	1. bhuvanakośa
16. golavarṇana	2. golasvarūpa	2. madhyabhukti
17. rāhunirākaraṇa	3. bhuvanakośa	3. chedyaka
18. grahopapattivarṇana	4. madhyagati	4. maṇḍalavarṇana
19. yantra	5. sphuṭagati	5. yantra
20. praśna	6. golabandha	6. ṛtuvarṇana
	7. tripraśna	
	8. grahaṇa	
	9. dṛkkarma	
	10. śṛṅgonnati	
	11. yantra	
	12. ṛtuvarṇana	
	13. praśna	

[1] The *jyotpatti* is variously placed in various editions.

(Table 4 cont.)

SR	SSBM	STV
I gaṇita	I pūrvārdha	
1. mīmāṃsā	1. madhyama	1. māna
2. madhyama	2. spaṣṭa	2. madhyama
3. spaṣṭa	3. tripraśna	3. spaṣṭa
4. tripraśna	4. grahacchāyā	4. tripraśna
5. candragrahaṇa	5. śṛṅgonnati	5. bimba
6. sūryagrahaṇa	6. grahabhāstodaya	6. chāyā
7. śṛṅgonnati	7. grahayoga	7. śṛṅgonnati
8. bhagrahayuti	8. grahaṇadvaya	8. udayāsta
9. bhagrahāṇām unnatāṃśa	9. krāntisāmya	9. parvasambhava
		10. candragrahaṇa
		11. sūryagrahaṇa
II gola	II uttarārdha	12. bhagrahayuti
1. bhuvanakośa	1. avanigolaja	13. pāta
2. golabandha	2. yantra	14. mahāpraśna
3. yantra	3. praśna	15. granthopasaṃhāra

Brahmā, Sūrya, Soma, Vasiṣṭha, and Pulastya are mentioned as agreeing with his Saurapakṣa parameters in the Siddhāntasundara[90] (1, 1, 25) by Jñānarāja,[91] who wrote this work at Pārthapura on the Godāvarī in 1503; that by Brahmā he means the *siddhānta* belonging to the Śākalyasaṃhitā is clear from SSJ 2, 1, 3. This work basically follows Lalla's arrangement, but like the SŚB it adds an *ṛtuvarṇana* (SSJ 2, 6). A commentary, Grahagaṇita-cintāmaṇi, was written by Jñānarāja's son, Cintāmaṇi,[92] in about 1530.

The influence of Islamic Ptolemaic theory upon Indian astronomy can be traced back to Muñjāla in the tenth century, but the translation of Persian astronomical treatises in some number into Sanskrit began only in the sixteenth and seventeenth centuries. The works selected for translation were for the most part the products of the School of Marāgha and its descendant at Samarqand; among the treatises so translated were the Zīj of Ulugh Beg[93] (Jīca Ulugbegī) and al-Qūshjī's[94] Risālah dar hay'at (Hayatagrantha[95]). The earliest Sanskrit *siddhāntas* to reflect this Islamic influence were composed at the Mughal court at Delhi by Nityānanda[96] during the reign of Shāh Jahān; he wrote the Siddhāntasindhu for Āsaf Khān in 1628, and the Siddhāntarāja[97] in 1639. While accepting Islamic parameters and models, Nityānanda presents his material in traditional form and puts forth the claim (copied from the Jñānabhāskara) that this astronomy had originally been revealed to the Yavana (Muslim) by the Sun, who was temporarily incarnate as Romaka (a Roman, or perhaps Qāḍī Zādah al-Rūmī). This Indianized presentation failed to convey to Sanskrit scholars the real superiority of Islamic over Indian astronomy, that is its methodology involving both a reliance on carefully planned and executed observations and a concern with the cinematics of the planetary models. Nityānanda's efforts produced no discernible effects.

His contemporaries in Kāśī, however, did not ignore Islamic astronomy, though some were more receptive than others. The two *siddhāntas* written there in the middle of the century follow the Saurapakṣa with some influence from Bhāskara's SŚB. Munīśvara,[98] who had earlier composed the gigantic Marīci on the SŚB, completed his Siddhāntasārvabhauma[99] in 1646. While willingly accepting some Islamic trigonometry and rather indifferently refer-

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[90] Unpublished. I have consulted the manuscripts IO 2002; BM Add. 14, 365p; and Oxford CS d. 805 (5).

[91] CESS A 3, 75a—76a, and A 4.

[92] CESS A 3, 49b.

[93] CESS A 4.

[94] CESS A 4.

[95] Edited by V. Bhaṭṭācārya, SBG 96, Vārāṇasī 1967; see Pingree in JHAS 2 (1978), 326—328.

[96] CESS A 3, 173b—174a, and A 4.

[97] Pingree in JHAS 2 (1978), 323—326.

[98] CESS A 4.

[99] I 1, 1—3, 133 with Munīśvara's own commentary were edited by Gopīnātha Kavirāja, PWSWT 41, 2 vols., Benares 1932—35.

ring to certain doctrines of the Pārasīkas (Persians), Munīśvara vigorously attacks the theory of precession,[100] thereby beginning a heated controversy carried on by Raṅganātha, the brother of his rival, Kamalākara, in his Lohagolakhaṇḍana, to which Munīśvara's cousin, Gadādhara,[101] replied in his Lohagolasamarthana.[102] Munīśvara wrote his own commentary, the Āśayaprakāśinī, on the SSBM.

Kamalākara,[103] who wrote the Sauravāsanā on the SS and completed the Siddhāntatattvaviveka[104] in 1658, while accepting the Saurapakṣa's planetary parameters, was far more receptive to Muslim astronomy as represented by Ulugh Beg and the School of Samarqand.[105] He was, in particular, prone to agree with Muslim (Ptolemaic) notions of the structure of the planetary system, and he presents what is, apparently, the only Sanskrit treatise on geometrical optics (STV 1, 5).

This process of transmitting Islamic astronomy to India was carried much further by the translation of Naṣīr al-Dīn's Arabic version of Ptolemy's Σύνταξις μαθηματική into Sanskrit by Jagannātha[106] at Jayapura in 1732 under the patronage of Savāī Jayasiṃha.[107] The Siddhāntasamrāṭ[108] continues after the thirteenth book of Ptolemy with supplements describing the instruments that Jayasiṃha had set up in his observatories in imitation of those installed by Ulugh Beg at Samarqand, and an exposition of Ulugh Beg's and al-Kāshī's derivations of sines, followed by remarks on the traditional aspects of Indian astronomy that were not touched upon by Ptolemy.[109] This last effort to expound Ptolemaic astronomy in Sanskrit was also doomed to fail; a century later, modern European astronomy was being taught in Sanskrit at Sihore by Somanātha Vyāsa[110] and other paṇḍits of the Sihore High School[111] in the 1830's and 1840's under the influence of Englishmen such as Lancelot Wilkinson. The process of Westernization was practically complete by the time Premavallabha[112] wrote his Paramasiddhānta[113] at Jayapura in 1882.

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[100] PINGREE in JHAS 2 (1978), 321—322.

[101] CESS A 2, 115a.

[102] Both works were edited by M. H. OJHA, LG 15, Benares 1961.

[103] CESS A 2, 21a—23a, A 3, 18a; and A 4.

[104] Edited with Kamalākara's Śeṣavāsanā by S. DVIVEDIN, BSS 1, Benares 1885; 2nd ed. by MURALĪDHARA JHĀ, Benares 1924—35; also edited by GAṄGĀDHARA MIŚRA, Lucknow 1929.

[105] PINGREE in JHAS 2 (1978), 322—323.

[106] CESS A 3, 56a—58a, and A 4.

[107] CESS A 3, 63a—64b, and A 4.

[108] Edited by R. S. ŚARMAN, 3 vols., New Delhi 1967—69.

[109] PINGREE in JHAS 2 (1978), 328—329.

[110] N. V. ATHALEY, "Kalandikā-Prakāśa of Somanātha Vyāsa," A Volume of Studies in Indology Presented to Prof. P. V. KANE, POS 75, Poona 1941, pp. 39—48.

[111] Cf. CP, Kielhorn XXIII 104: the Bhūbhramavādakhaṇḍananirāsa of the Sīhoragrāmasthasabhā, a manuscript dated Śaka 1761 = A.D. 1839.

[112] CESS A 4.

[113] Published at Mumbaī in 1896.

Karaṇas

Karaṇas outside of South India are distinguished from *siddhāntas* by their emphasis on pragmatic rules for computing and their avoidance of astronomical theory. One way in which this practical bent is most obviously manifested is by the elimination of reliance on the theory of the Kalpa or of the Mahāyuga in determining the mean motions of the planets; their mean longitudes are rather computed from their positions at a given epoch close in time to the date of the composition of the *karaṇa*, and the longitudes of the planets' apogees and nodes (except for the Moon's) are considered to be fixed. Before the Kh, of course, both *karaṇas* and *siddhāntas* bore the latter designation.

The earliest *karaṇa* that we know of, as mentioned previously, is the Sūrya-siddhānta of Lāṭadeva, an Ārdharātrika text summarized in the Pañcasiddhāntikā; its epoch was 21 March 505, as were also those of Lāṭadeva's recensions of the Romaka and Pauliśa *siddhāntas* epitomized in the PS.[114] Varāhamihira, the author of the PS, was a Maga Brāhmaṇa from Avanti who resided in a village named Kāpitthaka (probably Kāyathā near Ujjayinī[115]). It has further been suggested that he was connected with the Aulikara court at Daśapura, and in particular with Yaśodharman who was ruling there in 532. In the PS, besides the summaries of the five *siddhāntas* of Pitāmaha, Vasiṣṭha, Romaka, Pauliśa, and Sūrya that we have previously discussed, Varāhamihira includes chapters on spherical trigonometry (PS 4; entitled *karaṇa*), on the first visibility of the Moon (PS 5), on cosmology (PS 13), on instruments and observations (PS 14), and on differences in observed phenomena and time measurements due to such causes as local latitude or longitude and various conventions (PS 15). The PS was one source of the Chinese Chiu-chih li[116] written at the T'ang court by Ch'ü-t'an Hsi-ta (Gautama Siddhārtha) in 718.

An abbreviated *karaṇa*, dealing almost exclusively with calendaric matters, spherical trigonometry, and the computation of the positions of the planets, is the Dhyānagrahopādhyāya, preserved in some manuscripts of Brahmagupta's BSS as its last chapter (BSS 25). Its epoch is 21 March 628. Like the

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[114] The views of T. S. Kuppana Shastri, "The Epoch of the Romaka Siddhānta in the Pañcasiddhāntikā, and the Epoch Longitudes of the Sun and Moon in the Vāśiṣṭha-Pauliśa," IJHS 13 (1978), 151—158, are too involved to be argued against here. In general, his solution violates the principles that a lectio difficilior which makes sense is preferable to the lectio facilior that smells of being a learned emendation, and that modern astronomical computations must not be used to revise a manuscript tradition unless there is some substantial reason to believe that that tradition has misrepresented the author's original and that the original must have been in agreement with the modern computations.

[115] D. G. Dhavale, "The Kāpitthaka of Varāhamihira," IJHS 9 (1974), 77—78.

[116] K. Yabuuti, "Researches in the Chiu-chih li—Indian Astronomy under the T'ang Dynasty," Acta Asiatica 36 (1979), 7—48.

BSS itself it follows the Brāhmapakṣa, though a new method of approximating all linear and sine-wave functions by multiplying one of each by various simple coefficients is introduced. This and other approximative devices alter the parameters somewhat from those standard to the *pakṣa*.

But the *karaṇa* that set the pattern for this genre was the Khaṇḍakhādyaka[117] of Brahmagupta, whose epoch is 23 March 665. The first nine *adhikāras* present the astronomy of the Ārdharātrikapakṣa. The mean motion of each of the planets is presented as on integer number of rotations in a given number of days increased or decreased by a small corrective factor in another, larger number of days; this method was popular in later *karaṇas*. The last six *adhikāras* form the Uttarakhaṇḍakhādyaka; they provide correctives to the first, usually changing the Ārdharātrika into Brāhma parameters. The influence of the Kh was enormous; it remained the standard *karaṇa* of Kāśmīra, Nepāla, and Assam till modern times, but in the medieval period was popular throughout North and West India. In 735 a Zīj al-Arkand[118] based on it was composed in Sind, and, like the BSS, it was available to al-Bīrūnī[119] in the Panjāb in the 1020's. There are extant commentaries written by Pṛthūdakasvāmin (Vivaraṇa) at Sthāneśvara in 864; by Bhaṭṭotpala[120] (Cintāmaṇi) in Kāśmīra in 969; by Āmarāja[121] (Vāsanābhāṣya) at Ānandapura in Saurāṣṭra in about 1200; and by Yāmaṭa, Varuṇa, and Śrīdatta. As is normally the case with such practical texts as *karaṇas* and *koṣṭhakas*, virtually every manuscript represents a different recension. Also, as frequently occurs with *karaṇas*, there is a *koṣṭhaka* based on the Khaṇḍakhādyaka, the Khaṇḍakhādyakasāriṇī.[122]

There is nothing known of *karaṇas* written in the eighth and ninth centuries, though presumably the genre did not totally disappear. Nor do we possess any portion in Sanskrit of the Karaṇasāra written by Vaṭeśvara at Ānandapura in 899; that is preserved only in some quotations in the India, Transits, and Al-Qānūn al-Mas'ūdī of al-Bīrūnī.

Al-Bīrūnī also refers in the India to two *karaṇas* by Muñjāla.[123] The Bṛhan-

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[117] Edited with the commentary of Āmarāja by B. Miśra, Calcutta 1925; with the commentary of Pṛthūdakasvāmin by P. C. Sengupta, Calcutta 1941; and with the commentary of Bhaṭṭotpala and an English translation by B. Chatterjee, 2 vols., Calcutta 1970; for the missing portion of the first edition see Chatterjee's edition, vol. 1, pp. 170—174, and for the missing portion of the last edition see D. Pingree, "The Beginning of Utpala's Commentary on the Khaṇḍakhādyaka," JAOS 93 (1973), 469—481. There is an English translation by P. C. Sengupta, Calcutta 1934.

[118] F. I. Haddad, E. S. Kennedy, and D. Pingree, The Book of the Reasons behind Astronomical Tables, Aleppo, sec. 4, and D. Pingree, The Scholar and the Saint, p. 79, fn. 13.

[119] D. Pingree, The Scholar and the Saint, p. 79, fn. 14.

[120] CESS A 4.

[121] CESS A 1, 50a—50b, and A 2, 15a—15b.

[122] SATE 175—176.

[123] CESS A 4.

mānasa, whose epoch is 9 March 932, is now lost except for some fragments; but we still possess the Laghumānasa,[124] which Muñjāla composed later at Prakāśa on the Tāpī in Mahārāṣṭra. This small *karaṇa* has drawn elements from both the Āryapakṣa (as corrected by Lalla) and the Ārdharātrikapakṣa; it has also, apparently, derived the notion of the second inequality in lunar motion from an Islamic Ptolemaic source. Though it is a *karaṇa*, the LM does not give epoch positions (apparently one was expected to use those of the Bṛhanmānasa), and its contents are arranged in the form of a *siddhānta*. There are commentaries on the LM written by Praśastadhara (or Praśastidhara)[125] (Vivṛti) in Kāśmīra in 958; by Sūryadeva Yajvan (Grahajñānavāsanā) in 1248 at Gaṅgāpura in Cola country;[126] by Parameśvara (Pārameśvara) at Aśvatthagrāma in Kerala in 1409; and by Yallaya (Kalpalatā) at Skandasomeśvara in Āndhrapradeśa in 1482.

Like the KS of Vaṭeśvara, the Karaṇatilaka composed by Vijayananda (or Vijayanandin) in Vārāṇasī is known to us only through al-Bīrūnī, for whom it was incompetently translated into Arabic in 1026 as the Ghurrat al-zījāt.[127] The epoch of this, the first *karaṇa* of the Saurapakṣa, is 23/24 March 966.

In the early eleventh century the court of Bhojarāja,[128] the Paramāra Mahārāja of Dhārā, produced numerous works of Sanskrit literature. Among them is a *karaṇa* of the Brāhmapakṣa, containing (as does the more or less contemporary SŚŚ) the *bījas* that were utilized by most of the succeeding adherents of this *pakṣa*. The Rājamṛgāṅka, whose epoch is 21 February 1042, is not preserved for us in its original form, as most of the verses quoted from it by, for example, Āmarāja in his Vāsanābhāṣya on the Kh, are not found in the manuscripts.[129] A version by one Rāma[130] contains many verses in common with two manuscripts at Baroda,[131] though each of the three versions also contains a number of verses not in the other two. Moreover, all three versions comprise only the first two *adhikāras: madhyamagrahānayana* and *spaṣṭīkaraṇa*. The RM is sometimes accompanied by tables *(sāraṇī)*, but these have yet to be investigated.

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[124] Edited with the commentary of Parameśvara by B. D. Āpaṭe, ASS 123, Poona 1944, 2nd ed. Poona 1952, and with an English translation and notes by N. K. Majumdar, Calcutta 1951.

[125] CESS A 4.

[126] An edition is being prepared by K. V. Sarma; see his edition of the Āryabhaṭīya with Sūryadeva's commentary, pp. xxxix–xli.

[127] S. S. H. Rizvi, "A Unique and Unknown Book of al-Bīrūnī: Ghurrat-uz-Zījāt or Karaṇa Tilaka," IC 37 (1963), 112–130, 167–187, and 223–245: 38 (1964), 47–74 and 195–212; and 39 (1965), 1–26 and 137–180 (incomplete).

[128] CESS A 4.

[129] K. S. Shukla, "A Note on the Rāja-mṛgāṅka of Bhoja Published by the Adyar Library," Gaṇita 5 (1954), 149–151.

[130] K. M. K. Sarma, "The Rājamṛgāṅka of Bhoja," Brahmavidyā 4 (1940), 95–105.

[131] Baroda 3273 and 9476.

A popular *karaṇa* belonging to the Āryapakṣa is the Karaṇaprakāśa[132] composed by Brahmadeva[133] at Mathurā (probably Madurai in South India); its epoch is 11 March 1092. There is a commentary (Vṛtti) by Dāmodara,[134] who also wrote in West India an Āryatulya based on the A in 1417 and a Sūryatulya based on the SS; and there are undated commentaries by Amareśa[135] (Vyākhyāna) in Karṇāṭakī; by Govinda[136] (Vivaraṇa or Vivṛti) on the first two *adhikāras;* by Śrīnivāsa Yajvan (Karaṇaprakāśaprabhā); and by Sampatkumāra (Vyākhyā). Both the manuscripts of the KP and its commentators come predominantly from South and West India, and especially from Mysore and Mahārāṣṭra.

Śatānanda composed the Bhāsvatī,[137] a *karaṇa* following the Ārdharātrikapakṣa, allegedly at Puruṣottama (Puri in Orissa), in 1099. He claims to follow the SS as taught by (Varāha)mihira, but offers far more than is found in the PS; the B is sometimes entitled Pañcasiddhāntikā after its source. As is the case with many of these *karaṇas*, there are numerous recensions of the B; some manuscripts add an Uttarabhāsvatī. The principle commentaries are those composed by Aniruddha[138] (Śiśubodhinī) at Benares in 1495; by Gaṇapati[139] (Vivṛti) in Bengal in about 1500; by Mādhava[140] (Mādhavī) at Kānyakubja in 1525; by Acyuta[141] (Ratnamālā) in the 1530's, probably in Bengal; by Balabhadra[142] (Bālabodhinī) at Umānagara in Jumilādeśa, Nepāla, in 1543; by Kuvera Miśra[143] (Ṭīkā) in 1685; by Gaṅgādhara[144] (Udāhṛti) in 1685; by Rāmakṛṣṇa (Tattvaprakāśikā) in 1739; by Kamalanayana[145] in about 1740(?), probably in Mithilā; and by Yogīndra in 1742, apparently also in Mithilā. The distribution of the B's manuscripts and its commentators demonstrates its popularity in North and Northeast India and in Nepal.

But a more popular *karaṇa* in West and Northwest India is the Karaṇakutūhala[146] composed by Bhāskara in the Sahyādri in accordance with the Brāhma-

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132 Edited with his own commentary by S. Dvivedin, CSS 23, Benares 1899.
133 CESS A 4.
134 CESS A 3, 100b—101a.
135 CESS A 1, 45b.
136 CESS A 2, 135b—136a.
137 Published at Benares in 1854; with the commentary of Mādhava in Aruṇodaya 1 (1890—91); with his own Sanskrit and Hindī commentaries by Mātṛprasāda Pāṇḍeya, Benares 1917; and with his own commentary by Ṭīkārāma Dhanañjaya, Vārāṇasī [ND].
138 CESS A 1, 43b.
139 CESS A 2, 89a—89b.
140 CESS A 4.
141 CESS A 1, 36a—36b.
142 CESS A 4.
143 CESS A 2, 47b.
144 CESS A 2, 85a.
145 CESS A 2, 20a.
146 Edited with the commentary of Sumatiharṣa by M. S. Purohita, Mumbaī 1901.

pakṣa; its epoch is 23 February 1183. There are commentaries composed by Ekanātha[147] (Brahmatulyabhāṣya) at Mahāṇḍanagara, apparently in West India, in about 1370; by Padmanābha[148] (Nārmadī), probably also in West India, in about 1400; by Viśvanātha (Brahmatulyodāharaṇa) at Benares in 1612; and by Sumatiharṣa Gaṇi (Gaṇakakumudakaumudī) near the Vindhyādri in 1621. The Karaṇakutūhalaṭīkā of Soḍhala was composed before 1462, the date of its unique manuscript copy,[149] and that of Caṇḍīdāsa[150] before 1658. There is a set of planetary tables, the Brahmatulyasāriṇī,[151] based on the KK.

As in the case of Bhāskara's SŚB, the KK of Bhāskara was followed by several centuries during which no new member of the genre was produced. However, in the early sixteenth century Gaṇeśa[152] at Nandigrāma in Gujarāt wrote the Grahalāghava[153] or Siddhāntarahasya, apparently based on the Grahakautuka composed in 1496 by his father, Keśava;[154] the epoch of the GL is 18 March 1520. A commentator on the GL, Mallāri, states that Gaṇeśa observed the planets and chose the correct parameters from the Brāhmapakṣa, the Āryapakṣa, and the Saurapakṣa; this story obviously conflicts with the alleged relation of the GL to Keśava's Grahakautuka. In fact, the mean motions of the planets (given for *dhruvāṅkas* of 4,016 days) and their equations are unique to the Gaṇeśapakṣa, of which the GL is the first text as yet available (I have not been able to consult any manuscript of the Grahakautuka). The Gaṇeśapakṣa soon competed with the Brāhmapakṣa in West and Northwest India. Commentaries on it were composed by Gaṇeśa's nephew and pupil

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147 CESS A 1, 60a.

148 CESS A 4.

149 BORI 296 of 1882/83.

150 CESS A 3, 40a—40b.

151 SATIUS 36a—37a.

152 CESS A 2, 94a—100a; A 3, 27b—28a; and A 4.

153 Edited with the commentary of Mallāri by L. WILKINSON, Calcutta 1843; edited with the commentaries of Mallāri and Viśvanātha by BHĀLACANDRA, Kāśī 1865; edited with the commentary of Viśvanātha and a Marāṭhī translation by K. Ś. GOḌABOLE and V. K. J. GADRE, 2nd ed., Bombay 1873, 5th ed., Poona 1914, and 6th ed., Poona 1926; edited with the commentary of Mallāri, Mumbaī 1875, Benares 1877, Dillī 1877, Bombay 1882, Mumbaī 1883, Calcutta 1886; edited with the commentary of Viśvanātha and a Bengālī translation by RASIKAMOHANA CAṬṬOPĀDHYĀYA, Calcutta 1887; edited with the Hindī translation of JIYĀRĀMA ŚĀSTRĪ by RĀMEŚVARA BHAṬṬA, Kalyāṇa-Bombay 1889; edited with the commentary of Mallāri by HARIPRASĀDA ŚARMAN, Bombay 1901; edited with the commentaries of Mallāri and Viśvanātha by SUDHĀKARA DVIVEDIN, Benares 1904, reprinted Bombay 1925; edited with the commentary of Mallāri and the Telugu commentary of MAÑGIPŪḌI VĪRAYYA SIDDHĀNTIGĀR, Musalipatam 1915; edited with his own Sanskrit commentary and Hindī translation by SĪTĀRĀMA JHĀ, MM 142, Benares 1932, reprinted Benares 1941 and Dillī 1975; edited with the commentaries of Viśvanātha and YUGEŚVARA JHĀ and a Hindī commentary by KAPILEŚVARA ŚĀSTRIN, KSS 142, Benares 1946; and edited with the commentary of Mallāri and his own Hindī *ṭīkā* by RĀMACANDRA PĀṆḌEYA, Jambu 1976.

154 CESS A 2, 65b—74a; A 3, 24a; and A 4.

Nṛsiṃha,[155] who was born at Nandigrāma in 1548 (Harṣakaumudī); by Mallāri,[156] the son of Gaṇeśa's pupil, Divākara, at Golagrāma on the Godāvarī between 1575 and 1600 (Ṭīkā); by Gaṅgādhara[157] in 1586, probably at Ṭāpara north of Devagiri, his father Nārāyaṇa's residence (Manoramā); by Viśvanātha at Kāśī in 1612 (Siddhāntarahasyodāharaṇa); by Nārāyaṇa[158] at Kāśī before 1635 (Udāhṛti); and by Kamalākara[159] before 1662 (Manoramā). There are many tables based on the GL, many using the ends of the various *dhruvāṅkas* as their epochs.[160]

At Akbar's court a *karaṇa* belonging to the Saurapakṣa, the Rāmavinoda,[161] was composed by Rāma (or Rāmacandra) for a *bhūpāla* also named Rāma (or Rāmadāsa). Its epoch is 11 March 1590, which is stated to be thirty-five years after the era of Akbar; the epoch of Akbar's "Divine Era," which was introduced on Nawrūz of 1584, was indeed 11 March 1556. A commentary, Rāmavinodadīpikā, was written by Viśvanātha at Kāmpilya shortly after 1602. There is also a *koṣṭhaka* written by Rāma and bearing the same name as the RV.

A far more obscure *karaṇa* is the Laghukaraṇa[162] by Bhāvasadāśiva.[163] Its epoch is 27 March 1598; it follows the Brāhmapakṣa; and its unique manuscript copy came to London from Gujarāt in 1809.

Somewhat better known is a Saura *karaṇa*, the Sūryapakṣaśaraṇa[164] or Khacarāgama composed by Viṣṇu; its epoch is 7 March 1608. A commentary, Udāharaṇa, was written on it by Viśvanātha already in 1612. The fact that the *karaṇa* belongs to the Saurapakṣa and that it was known to Viśvanātha within four years of its composition makes it likely that Viṣṇu lived in Benares, in which case he was probably the Viṣṇu who instructed Kṛṣṇa,[165] who wrote the Bījāṅkura in about 1600, and was himself the pupil of Gaṇeśa's nephew, Nṛsiṃha.

Another Kṛṣṇa[166] wrote a Karaṇakaustubha[167] following the Gaṇeśapakṣa

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155 CESS A 3, 202b—204a, and A 4.

156 CESS A 4.

157 CESS A 2, 82a—82b.

158 CESS A 3, 165b—166a, and A 4.

159 CESS A 2, 21a.

160 SATIUS 46b—47b (Anonymous of 1520: epoch 18 March 1520); SATE 98—100 (Grahalāghavasāriṇī IA: epoch 18 March 1520); SATIUS 50b (Grahalāghavīyamadhyamaspaṣṭārkasāriṇī: epoch 22 March 1525); SATE 93—98 (Grahalāghavasāriṇī I: epochs 17 March 1531 = *dhruvāṅka* 1; 13 March 1553 = *dhruvāṅka* 3; and 27 February 1641 = *dhruvāṅka* 11); and SATIUS 69a—70a (Grahalāghavasāriṇī II: epoch 2 April 1754).

161 I have consulted WHMRL Enfield 123, which contains both the *koṣṭhaka* RV, and a longer version of the *karaṇa*, and Oxford Sanskrit d. 805, which contains Viśvanātha's commentary on the *karaṇa*.

162 I have used IO 2494d.

163 CESS A 4.

164 I have used WHMRL V 33.

165 CESS A 2, 53a—55b, and A 4.

166 CESS A 2, 55b—56a, and A 4.

167 Edited by V. G. Āpaṭe, ASS 96, **Poona 1927.**

at Taṭāka in the Koṅkaṇa under the Marāṭha monarch Śivājī; its epoch is 1653. A comparison of their respective chapter titles will demonstrate how closely the KKK follows the GL, whose system of astronomy it attempted to introduce into Mahārāṣṭra. The paucity of manuscripts suggests that it met with little enthusiasm.

The last *karaṇa* to which allusion must be made is the Karaṇavaiṣṇava[168] of Śaṅkara, which belongs to the Brāhmapakṣa; its epoch is 8 May 1766. Śaṅkara otherwise, in the incomplete manuscript available to me,[169] informs us only that his teacher's name was Nandabhaṭṭa. It is possible that this is the Nandarāma Miśra[170] who wrote various works on astronomy and astrology at Kāmyavana in Rājasthāna between 1763 and 1778; in favor of this tentative identification is the fact that Rājasthāna was one of the places in which the Brāhmapakṣa was popular.

Table 5

Kh	LM	KP
1. tithinakṣatra	1. madhyama	1. madhyama
2. tārāgrahasphuṭa	2. sphuṭagati	2. tithyādi
3. tripraśna	3. prakīrṇaka	3. spaṣṭa
4. candragrahaṇa	4. tripraśna	4. tripraśna
5. ādityagrahaṇa	5. grahaṇa[1]	5. candragrahaṇa
6. udayāstamaya	6. saṅkīrṇa[2]	6. sūryagrahaṇa
7. śṛṅgonnati		7. udayāsta
8. samāgama		8. śṛṅgonnati
9. tārāvikṣepa		9. grahayuti
Uttarakhaṇḍakhādyaka		
10. tithinakṣatrottara		
11. grahagatyuttara		
12. tithipraśnottara		
13. grahaṇottara		
14. udayāstamayottara		
15. samāgamottara		

[1] Grahayuti in Majumdar's edition.

[2] Divided into a *pāta* and a *candracchāyā* with *śṛṅgonnati* in Majumdar's edition.

[168] D. Pingree, "The Karaṇavaiṣṇava of Śaṅkara," Charudeva Shastri Felicitation Volume, Delhi 1974, pp. 588–600.

[169] Columbia, Smith Indic 144.

[170] CESS A 3, 128b–130b, and A 4.

B	KK
1. tithidhruva	1. nabhogamadhya
2. grahadhruva	2. sphuṭakriyā
3. pañcāṅga	3. tripraśna
4. grahasphuṭa	4. śaśāṅkaparva
5. tripraśna	5. ravigraha
6. candragrahaṇa	6. grahodayāsta
7. sūryagrahaṇa	7. śṛṅgonnati
8. parilekha	8. grahotthayoga
	9. pāta
	10. ravīnduparvasambhava
	11. nīradārkavicāra

GL	RV
1. madhyamā	1. madhyama
2. ravicandraspaṣṭa	2. spaṣṭa
3. pañcatārāspaṣṭīkaraṇa	3. tripraśna
4. tripraśna	4. candragrahaṇa
5. candragrahaṇa	5. sūryagrahaṇa
6. sūryagrahaṇa	6. parilekha
7. māsagaṇa	7. udayāsta
8. grahaṇadvaya	8. grahayuddha
9. udayāsta	9. grahanakṣatrayuti
10. grahacchāyā	10. śṛṅgonnati
11. nakṣatracchāyā	11. pāta
12. śṛṅgonnati	
13. grahayuti	
14. pāta	
15. pañcāṅgacandragrahaṇa	
16. upasaṃhāra	

LK	SPŚ	KKK
1. madhyama	1. madhyagraha	1. madhyamagraha
2. spaṣṭa	2. spaṣṭagraha	2. sūryacandraspaṣṭīkaraṇa
3. lagna	3. praśnatraya	3. pañcatārāspaṣṭīkaraṇa
4. candragrahaṇa	4. candragraha	2. tripraśna
5. sūryagrahaṇa	5. sūryagraha	5. candragrahaṇa
6. udayāsta	6. graha (= parva)	6. sūryagrahaṇa
7. grahayuti	7. candrekṣaṇa	7. grahaṇadvaya
8. śṛṅgonnati	8. astodaya	8. udayāsta
9. pāta	9. kheṭaprabhā	9. grahacchāyā
	10. śṛṅgonnati	10. candraśṛṅgonnati
	11. kheṭaikyatā	11. grahayuti
	12. ṛkṣaprabhā	12. nakṣatracchāyā
	13. pāta	13. pāta
	14. ghaṭi	14. granthālaṅkāra

KV
1. madhyama
2. grahaspaṣṭa
3. tripraśna
4. candragrahaṇa
5. sūryagrahaṇa
6. parilekha
7. udayāsta
8. candraśṛṅgonnati
9. grahayuti
10. nakṣatracchāyā
11. mahāpāta
12. sūkṣmanakṣatra
13. madhyamagraha
14. śīghraphala
15. udayāsta
16. miśrika

Koṣṭhakas[171]

Closely associated with *karaṇas* in North and West India since at least the twelfth century were astronomical tables (*koṣṭhakas* or *sāraṇīs*) which were intended to facilitate the computation of planetary positions and the cusps of the astrological places for those who cast horoscopes, or that of various calendaric functions such as *tithis*, *nakṣatras*, and *yogas* for the makers of almanacs *(pañcāṅgas)*. Tables had much earlier been an integral part of astronomical writings, in which they were versified along with the mathematical formulae. But the composing of tables using numerical symbols arranged in columns was apparently introduced into India as an imitation of Islamic *zījes*. The Indian genius for mathematical computation led them to develop many ingenious ways to present the complex elements of their planetary and calendaric models in tabular forms very different from those in use in Islam, but the ultimate derivation of the idea from the West seems unquestionable.

In fact, the earliest such *koṣṭhaka* concerning which we have any information is apparently the *zīj* composed by Durlabha[172] at Multān in Sind; its epoch is 932. Our only source of knowledge of this *zīj*, however, is al-Bīrūnī's India; and he quotes from the instructions rather than from the tables, which presumably accompanied those instructions if the work was indeed a *zīj*.

Planetary tables in India can be classified into three categories. "Mean linear" arrangements tabulate the increments in the mean longitudes of the planets in successively smaller units of time; the *manda* and *śīghra* equations are tabulated separately. This is the form of planetary table employed by Ptolemy and by most of his eastern and western successors. The "true linear" arrangement tabulates the true longitudes of the planets in ideal years at given intervals *(avadhis)*. The ideal years assume initial mean longitudes of the planet at equal distances around the zodiac while the initial mean longitude of the Sun is always at Aries 0°; the intervals between the initial mean longitudes that are attested are 3°, 6°, 12°, 13;20° (a *nakṣatra*), and 30°. Mean motion tables in terms of these intervals allow one to locate the planet within this system for any given year. The *avadhis* are normally periods of fourteen days. The "true linear" arrangement seems to be an Indian invention. Finally, the "cyclic" arrangement utilizes the Babylonian goal-year periods (that of Venus is changed from 8 to 227 years). The planet's true longitude for the beginning of each *avadhi* in each year of its goal-year period is entered in the table; after one period the cycle is repeated. The goal-year periods themselves were introduced into Indian astronomy from Islamic in the early seventeenth century;[173] the "cyclic" tables

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[171] On astronomical tables see D. PINGREE, SATIUS, SATE, and "On the Classification of Indian Planetary Tables," JHA 1 (1970), 95—108.

[172] CESS A 3, 116b.

[173] D. PINGREE in JHAS 2 (1978), 319—320.

produced in that century and the succeeding two in West and Northwest India combined these goal-year periods with the native tradition of true linear tables.

The planetary tables that have been studied heretofore are as follows.[174]

1. The Grahajñāna[175] by Āśādhara,[176] belonging to the Brāhmapakṣa. Its epoch is 20 March 1132; it is true linear. Apparently written in Gujarāt. Expanding the instructions for using these tables is the Gaṇitacūḍāmaṇi composed by Harihara in Gujarāt in about 1580.

2. The Laghukhecarasiddhi[177] of Śrīdhara, also belonging to the Brāhmapakṣa. Its epoch is 20 March 1227; it is mean linear. Probably written in Khāndeśa.

3. The Mahādevī[178] of Mahādeva,[179] again belonging to the Brāhmapakṣa. Its epoch is 28 March 1316; it is true linear. Written on the banks of the Godāvarī, most probably in Mahārāṣṭra.

4. The Makaranda[180] of Makaranda,[181] belonging to the Saurapakṣa and including *tithi*, *nakṣatra*, *yoga*, and eclipse as well as planetary tables. Its epoch is 27 March 1478; it is mean linear, and the only set of mean motion tables that is entirely sexagesimal. Written at Kāśī.

5. The Kheṭamuktāvalī[182] of Nṛsiṃha,[183] belonging to the Gaṇeśapakṣa. Its epoch is 31 March 1566; it is true linear. Written at Nandigrāma in Gujarāt.

6. The Candrārkī[184] and the Kheṭasiddhi[185] of Dinakara,[186] belonging to the Brāhmapakṣa. The former deals with the Sun and Moon, the latter with the other planets. Their epoch is 31 March 1578; they are true linear. Written at Bārejya in Gujarāt.

7. The Grahakaumudī[187] of Nṛsiṃha, the author of the Kheṭamuktavalī to whose Gaṇeśapakṣa the Grahakaumudī also adheres. Its epochs are 31 March 1588 and 31 March 1603; it also is true linear. Written at Nandigrāma in Gujarāt.

8. The Rāmavinoda[188] of Rāma, who wrote the Saura *karaṇa* of the same name. Its epoch is 11 March 1590; it is true linear. Written at the Mughal court.

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[174] The texts that accompany them are edited by D. PINGREE in a collection entitled Minor Astronomical Texts in Sanskrit, shortly to be published in the GOS.

[175] SATE 69—72.

[176] CESS A 1, 54b; A 2, 16a; A 3, 16a; and A 4.

[177] SATE 73—76; and D. PINGREE, Śrīdhara's Laghukhecarasiddhi, Baroda 1976.

[178] SATIUS 37a—39a; SATE 82; and O. NEUGEBAUER and D. PINGREE, "The Astronomical Tables of Mahādeva," PAPhS 111 (1967), 69—92.

[179] CESS A 4.

[180] SATIUS 39b—46b, and SATE 92.

[181] CESS A 4.

[182] D. PINGREE, "The Kheṭamuktāvalī of Nṛsiṃha," Sanskrit and Indian Studies, Essays in Honour of D. H. H. Ingalls, Dordrecht 1980, pp. 143—157.

[183] CESS A 3, 202b—204a, and A 4.

[184] SATIUS 51b—53a, and SATE 101.

[185] SATE 101—112.

[186] CESS A 3, 102b—104b, and A 4.

[187] SATE 118—123 and D. PINGREE in Sanskrit and Indian Studies, pp. 149—156.

[188] SATE 114—118.

9. The Ravisiddhāntamañjarī[189] of Mathurānātha,[190] belonging to the Saurapakṣa. Its epoch is 29 March 1609; it is mean linear. It includes parallax-tables for use in computing solar eclipses. Probably composed in Bengal.

10. The Grahaprabodha[191] of Nāgeśa,[192] which follows the Gaṇeśapakṣa. Its epoch is 5 March 1619, the beginning of *dhruvāṅka* 9; it is mean linear. Written in Gujarāt. There is an *udāharaṇa* by Yādava, in which the example is for 9 December 1663.

11. The Khecaraśīghrasiddhi or Grahasāraṇī[193] of Gaṅgādhara,[194] also belonging to the Gaṇeśapakṣa. Its epoch is 1 March 1630, the beginning of *dhruvāṅka* 10; it is mean linear. It includes tables for computing eclipses. Written at Kāśī.

12. The Grahavidyādhara[195] of Vidyādhara. The tables themselves are not preserved, but Vidyādhara states that they belonged to the Brāhmapakṣa. Its epoch is about 29 March 1638; it is mean linear. Written at Rājakoṭa in Saurāṣṭra.

13. The Jagadbhūṣaṇa[196] of Haridatta, belonging to the Brāhmapakṣa. Its epoch is 31 March 1638; it is the first set of cyclic planetary tables. Written in Mewar, Rājasthān.

14. The Khecaradīpikā[197] of Kalyāṇa,[198] also following the Brāhmapakṣa. Its epoch is 31 March 1649; it is true linear, being an adaptation of the Mahādevī. The fact that two of its verses are derived from the Candrārkī of Dinakara support the impression that it was composed in Gujarāt or Rājasthān.

15. The Grahaprakāśa[199] of Devadatta,[200] belonging to the Adjusted Saurapakṣa. Its epoch is 28 March 1662; it is mean linear. As his nephew Murāri traveled to Kāśī in order to bathe at Maṇikarṇikā, Devadatta probably did not live in that city; but nothing positive is known concerning his locale.

16. The Kheṭataraṅgiṇī[201] of Āpadeva,[202] belonging to the Gaṇeśapakṣa. Its epoch is 18 March 1702; it is mean linear. Written at Janasthāna in Mahārāṣṭra.

17. The Grahasiddhi and Bhramaṇasāraṇī of Trivikrama,[203] the tables of which are probably those of the Anonymous of 1704,[204] which belong to the

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189 Edited by Viśvambhara Jyotiṣārṇava, BI 198, Calcutta 1911; see SATE 128—134.
190 CESS A 4.
191 SATIUS 63a—64b.
192 CESS A 3, 145b—146b, and A 4.
193 SATE 134—141.
194 CESS A 2, 82b—85a, and A 4.
195 I have used IO 2083c.
196 SATIUS 55b—59b, and SATE 141—142.
197 SATIUS 61b—62b.
198 CESS A 2, 25b.
199 SATE 142—149.
200 CESS A 3, 118b—119a.
201 I have used Baroda 3095.
202 CESS A 1, 49b—50a; A 3, 15b; and A 4.
203 CESS A 3, 92b—93b, and A 4.
204 SATIUS 64b—66a.

Brāhmapakṣa. Its epoch is 1 April 1704; it is cyclic. Composed at Nalinapura, presumably a locality in Rājasthān.

18. The Gaṇitarāja[205] of Kevalarāma Pañcānana[206] contains eclipse tables and *tithi*, *nakṣatra*, and *yoga* tables as well as planetary tables; it follows the Adjusted Saurapakṣa. Its epoch is 30 March 1728; it is mean linear. The equations are normed so as to be always positive; this feature was probably borrowed from Islamic tables. Written in Navadvīpa, Bengal.

19. The Grahāgama[207] of Govindasūnu,[208] belonging to the Gaṇeśapakṣa. Its epoch is 6 February 1773 Julian, which is the beginning of *dhruvāṅka* 23; it is mean linear. Composed at Śipośi, which is presumably a locality in Rājasthān.

A second category of *koṣṭhakas* that were popular in India provides tables for computing the beginnings (and ends) of *tithis* (periods during which the elongation of the Moon from the Sun increases by 12°), *nakṣatras* (periods during which the longitude of the Moon increases by 13; 20°), and *yogas* (periods during which the combined motion of the Sun and the Moon equals 13;20°). The computations of the true instances of the beginnings of *tithis* and *yogas* is made complex by the fact that both of the luminaries have varying velocities, the Sun's dependent on the distance of its mean longitude from a more or less fixed sidereal point (its *mandocca*) and the Moon's on the distance of its mean longitude from a constantly moving point (its *mandocca*). The solutions adopted by various Indian *koṣṭhakakāras* are not yet understood in their totality by the present writer. The *tithis*, *nakṣatras*, and *yogas* themselves needed to be tabulated for the convenience of astrologers computing *muhūrtas* and of the constructors of *pañcāṅgas* which informed the populace of the details of the calendar and the proper times for festivals and the performance of *saṃskāras*.

Several of the planetary tables contain also tables of *tithis*, *nakṣatras*, and *yogas;* these are the Makaranda of Makaranda, the Candrārkī of Dinakara, and the Gaṇitarāja of Kevalarāma Pañcānana discussed above. Independent *koṣṭhakas* on this subject include the following:

1. The Śīghrasiddhi[209] of Lakṣmīdhara, which tabulates functions according to both the Āryapakṣa and the Brāhmapakṣa. Its epoch is 1278, and it was probably composed in the territory of the Yādavas of Devagiri. The Śīghrasiddhi was expanded in 1618–1628 by Janārdana[210] at Saṅgamanera in Mahārāṣṭra; it was also used by Vidyādhara in 1643 at Rājakoṭa in Saurāṣṭra.

2. The Tithikāmadhenu[211] of Mahādeva,[212] following the Āryapakṣa. Its epoch is 1357, and it was composed at Tryambaka in Mahārāṣṭra.

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205 SATE 158–168.
206 CESS A 2, 63a, and A 4.
207 SATE 168–169.
208 CESS A 2, 143b, and A 4.
209 SATE 76–82.
210 CESS A 3, 59a, and A 4.
211 SATE 82–89.
212 CESS A 4.

3. The Daivajñavallabha[213] of Sumiśra, belonging to the Ārdharātrikapakṣa (the Khaṇḍakhādyaka). Its epoch is 1447, and it was written in Nepāla.

4. The Tithicintāmaṇi[214] of Gaṇeśa, the author of the Grahalāghava; naturally it follows his Gaṇeśapakṣa. Its epoch is 1525, and it was written at Nandigrāma in Gujarāt. There are commentaries by Nṛsiṃha, who wrote the Saurabhāṣya on the SS in 1611 and the Vāsanāvārttika on the SŚB in 1621, both in Kāśī; by Viśvanātha, who wrote in Kāśī in 1634; by Vyeṅkaṭa alias Bāpū Caṇḍika, who also wrote in Kāśī; and by Yajñeśvara.

5. The Bṛhattithicintāmaṇi,[215] also by Gaṇeśa and belonging to the Gaṇeśapakṣa. Its epoch is 1552, and it also was composed at Nandigrāma in Gujarāt. There is a commentary, Subodhinī, composed by Viṣṇu, the uncle of the Nṛsiṃha who commented on the Tithicintāmaṇi, in about 1575.

6. The Tithisāraṇi[216] of Dinakara, the author of the Candrārkī and the Kheṭasiddhi; this work belongs to the Brāhmapakṣa. Its epoch is 31 March 1583; and Dinakara wrote it at Bārejya in Gujarāt.

7. The Tithyādicintāmaṇi[217] of Dinakara.[218] Its epoch is 1586, and it was composed at Unnatadurga (Junāgaḍh in Saurāṣṭra).

8. The Tithikalpadruma[219] of Kalyāṇa,[220] also following the Brāhmapakṣa. Its epoch is 31 March 1605, and it was composed at Maṅgalapura in Saurāṣṭra.

9. The Camatkārasiddhi[221] of Vīrasiṃha,[222] one of the astronomers working for Anūpasiṃha,[223] the Mahārāja of Bikāner from 1674 to 1698. Its epoch is 1627.

10. The Pañcāṅgavidyādharī[224] by Vidyādhara, the author of the Grahavidyādhara; like Lakṣmīdhara's Śīghrasiddhi, much of which it copies, it tabulates functions according to the parameters of both the Āryapakṣa and the Brāhmapakṣa. Its epoch is 1643; it was composed for Vīrabhadra, the *rājā* of Rājakoṭa in Saurāṣṭra.

11. The Candrārkī[225] of Acalajit,[226] which transforms the tables of Dinakara

[213] I have used IO 3283e, the apparently unique manuscript.

[214] SATIUS 47b—50b and SATE 100—101. The Tithicintāmaṇi was edited with his own Hindī *ṭīkā*, Vijayalakṣmī, by MĀṬṚPRASĀDA PĀṆḌEYA, HSS 76, Benares 1938; and with the *udāharaṇa* of Viśvanātha by DATTĀTREYA ĀPAṬE, ASS 120, Poona 1942, pt. 1.

[215] SATIUS 50b—51a and SATE 101. The Bṛhattithicintāmaṇi with the *ṭīkā*, Subodhinī, of Viṣṇu, but without the tables, was edited by DATTĀTREYA ĀPAṬE, ASS 120, Poona 1942, pt. 2.

[216] SATE 112—114.

[217] SATIUS 51a—51b.

[218] CESS A 3, 104b—105a.

[219] SATE 123—128.

[220] CESS A 2, 24b—25a, and A 4.

[221] I have used Oxford CS d. 791 (9).

[222] See K. M. K. SARMA, "Vīrasiṃhagaṇaka," Brahmavidyā 9 (1945), 7—12.

[223] CESS A 1, 43b—44a.

[224] SATIUS 60b—61b and SATE 142.

[225] I have used Baroda 3120 and 3121.

[226] CESS A 4.

from the Brāhmapakṣa to the Saurapakṣa. Its epoch is 1655; Acalajit wrote at Muraripupura in Gujarāt.

12. and 13. The Tithidarpaṇa[227] and Laghutithidarpaṇa[228] of Murāri.[229] The former cannot be dated, but the latter, based on the Makaranda of Makaranda, a text belonging to the Saurapakṣa, has as its epoch 1665, and was composed in Kāśī.

14. The Jayavinodasāraṇī[230] ascribed to Savāī Jayasiṃha, the Mahārāja of Jayapura who sponsored Jagannātha's Siddhāntasamrāṭ in 1732. Its epoch is 1735.

15. The Pattraprakāśa[231] of Viśrāmaśukla, belonging to the Adjusted Saurapakṣa. Its epoch is 1750, but it seems to have been composed in 1777, in Kāśī. It appends true-linear planetary tables to those for *tithis*, *nakṣatras*, and *yogas*.

A final class of astronomical tables includes those designed for use in computing lunar and solar eclipses. Such tables are embedded in the Grahasāriṇī of Gaṅgādhara and the Gaṇitarāja of Kevalarāma, which have already been described. The only set of tables devoted exclusively to the subject of eclipses would seem to be the Karaṇakesarī[232] of Bhāskara.[233] Its epoch is 1681, and it was composed at Saudamika, evidently a locality in Gujarāt. However, specialized treatises on eclipse computations—e.g., the Parvadvayasādhana of Mallāri—frequently include versified tables; such texts are described more fully below.

The *koṣṭhakas* described in the preceding pages come mostly from western India with a few representatives of a tradition in Kāśī and Bengal. This bias reflects a real situation in the history of Indian astronomy to which we have previously referred—that is, the influence of the Islamic *zīj* on the Indian *koṣṭhaka*. However, other parts of India were not without such tables, though those known to me tend to be late.[234] Moreover, the next section of this chapter will describe texts containing versified tables used in South India in imitation of those found in *siddhāntas* and *karaṇas*. It was generally in this form that astronomical functions were tabulated in those parts of India not subject to a direct and profound Islamic influence.

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[227] SATE 149—150.
[228] SATE 151—153.
[229] CESS A 4.
[230] SATIUS 66b—67a.
[231] SATE 170—175.
[232] SATIUS 70b—72b; for the text I have referred to Baroda 11268.
[233] CESS A 4.
[234] E.g., SATE 178—182, and CESS A 1, 38b.

South Indian Astronomers[235]

The Dravidian speaking areas of the Indian peninsula—Āndhrapradeśa, Karṇāṭaka, Tamilnadu, and Kerala—developed traditions of astronomy (and mathematics) based on the Ārya and Saura *pakṣas*, but largely independent of the traditions in the rest of India; this insularity was particularly true of Kerala, where some of the most brilliant work ever to be done in India in mathematics was produced in the fourteenth and fifteenth centuries without having any effect whatsoever on the north. In the south in particular developed three interrelated systems: the Parahita and Vākya following the Āryapakṣa, and the Dṛggaṇita following the Saurapakṣa. Further, a genre of literature called *tantra* or *karaṇa* evolved in which the author could deal with selected topics in astronomy rather than giving a complete system as a *siddhānta* or northern *karaṇa* would. Alongside these texts, which are collections of problems, there were written short essays dealing with single facets of astronomy. To some extent, as we shall see, such essays were also composed in the north, but never in the numbers in which they were written in Kerala.

The Parahita system was first embodied in the Grahacāranibandhana[236] of Haridatta. Traditionally the date of the inception of the system was 683; since Haridatta is already quoted as an authority of Govindasvāmin in his Prakaṭārthadīpikā, written in the first half of the ninth century, 683 is not an unreasonable date for Haridatta. The GCN versifies the mean daily motions of the planets according to the Āryapakṣa, the sines of their equations at intervals in the argument of 3;45° (he calls these tables *vākyas*), the *śīghra* anomalies necessary for first and last stations, and the mean longitudes of the planets on 20 March 355; all of the numbers are expressed by the *kaṭapayādi* system. In another work—probably the lost Mahāmārganibandhana—Haridatta gave *bīja* corrections to the mean yearly motions of the planets, to be applied to the years following 522.

Following the Parahita system, and thereby the Āryapakṣa, are the *vākyas*. These are based on the synodic periods of the five planets and cycles based on those periods, and, in the case of the Moon, on cycles of its anomalistic period; within each synodic period true longitudes at regular time intervals are given, and in the smallest lunar cycle daily longitudes of the Moon are given.

The earliest attested epoch of the lunar *vākyas* is 1184. The *vākyas* themselves, called Candravākyāni[237] and attributed to Vararuci, use the relation: 9 anomalistic months = 248 days. The larger cycles of the system are: 110 anomalistic months = 3031 days, and 449 anomalistic months = 12,372 days. The two

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[235] The most recent general treatment of South Indian astronomers, astrologers, and mathematicians is K. V. Sarma, A History of the Kerala School of Hindu Astronomy, VIS 55, Hoshiarpur 1972.

[236] Edited by K. V. Sarma, Madras 1954.

[237] Edited by C. Kunhan Raja, Madras 1948.

smaller cycles had already been given by the Vasiṣṭhasiddhānta known to Varāhamihira (PS 3, 8–9); the first is ultimately Babylonian. Several Sanskrit poems composed in Kerala contain, embedded in their verses by means of the *kaṭapayādi* system, Vararuci's lunar *vākyas;* the most notable of these is the Haricarita[238] composed by Parameśvara[239] in the fifteenth century, in which the life of Kṛṣṇa provides the surface meaning for the versified astronomical tables. These *vākyas* were still in use in south India in modern times. They were described by John Warren in 1825[240] as part of a discussion of the *pañcāṅga*-computations; in this form, and misnamed "Tamil," they generated some interest among non-Indian historians of science in the 1950's and 1960's.[241]

The planetary *vākyas* are given in an anonymous text entitled Vākyakaraṇa,[242] in which the epoch of the lunar *vākyas* is 22 May 1282; the text seems to have been composed in about 1300, probably near Kāñcī. There is a commentary composed by Sundararāja, who was a native of Viprasadgrāma (Andaṇa-nal-lur near Trichinopoly), in the late fifteenth or early sixteenth century; Sundararāja studied under Padmagarbha during the reign of (Gopendra) Tipparāja,[243] who ruled Koṇḍavīḍu in the Guntur District for the Vijayanagara king, Kṛṣṇadeva Rāya, from about 1515 till 1520, and he corresponded with the well-known astronomer, Gārgyakerala Nīlakaṇṭha Somayājin, whom we shall presently discuss in more detail.

Before turning to the most important school of Kerala astronomers, I should mention the first text in a genre, the *tantra*, cultivated exclusively in south India. A *tantra* is like a *karaṇa* in its emphasis on pragmatic solutions to particular astronomical problems—sometimes only to those that were regarded as needing a special treatment. But since it follows the Āryapakṣa, in which there is a mean conjunction of all the planets at the beginning of the current Kaliyuga (6 A.M. at Laṅkā on 18 February–3101), a *tantra* uses that date as its epoch rather than a date closer in time to the author's.

The earliest such *tantra* is the Vārṣikatantra[244] written by Viḍḍaṇa or Viddaṇa. His own name and that of his father, Mallaya, indicate a Dravidian origin, probably in Mysore whence most of the manuscripts of his work come. The

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[238] Edited by V. KRISHNAMACHARYA, ALS 63, Madras 1948.

[239] CESS A 4.

[240] J. WARREN, Kala Sankalita, Madras 1825, pp. 118–146.

[241] O. NEUGEBAUER, "Tamil Astronomy," Osiris 10 (1952), 252–276; I. V. M. KRISHNA RAV, "The Motion of the Moon in Tamil Astronomy," Centaurus 4 (1956), 198–220; B. L. VAN DER WAERDEN, "Tamil Astronomy," Centaurus 4 (1956), 221–234; and G. J. TOOMER, "A Note on Tamil Astronomical Tables," Centaurus 9 (1963–1964), 11–15, and "A Further Note on Tamil Astronomical Tables," Centaurus 9 (1963–1964), 254–256.

[242] Edited with the commentary, Laghuprakāśikā, of Sundararāja by T. S. KUPPANNA SASTRI and K. V. SARMA, Madras 1962.

[243] CESS A 2, 133b.

[244] I have used the manuscript Harvard 1113 (Poleman 4391), in which II 5–III 10 are missing.

Vārṣikatantra was written before 1370 since it is quoted by Ekanātha in his commentary on Bhāskara's KK. It consists of eleven *adhyāyas* in a somewhat unusual order: *dhruvamadhya (=madhyama)*, *grahagatinirṇaya (=sphuṭa)*, *chāyā (=tripraśna)*, *candragrahaṇa*, *sūryagrahaṇa*, *valilekhana (=parilekha)*, *mahāpāta*, *udayāstamaya*, *grahayuti*, *bhagrahayuti*, and *śṛṅgonnati*. A manuscript was acquired in the Karṇāṭaka and brought to Bikāner in Rājasthān by the Mahārāja Anūpasiṃha[245] in about 1675; there the work was revised by the court astronomer, Vīrasiṃha, in 1678, and a set of *koṣṭhakas* calculated for it.

But the most important school of astronomers from south India was founded by its most brilliant member, Mādhava[246] of Saṅgamagrāma (near Cochin in Kerala), in the late fourteenth century. His most ingenious work was done in the investigation of the series that express the value of π and of other trigonometrical functions used in astronomy; this achievement is discussed more fully in the chapter on mathematics. The surviving astronomical works of Mādhava are for the most part concerned with refinements of the *vākya* system. They include, on the lunar *vākyas*, the Sphuṭacandrāpti;[247] its elaboration, the Veṇvāroha,[248] whose epoch is 1403; and a new set of Candravākyāni[249] giving daily longitudes of the Moon correct to the second sexagesimal place instead of to the first as in the Candravākyāni of Vararuci. The idea of the Sphuṭacandrāpti and the Veṇvāroha is to utilize the cyclic nature of the lunar *vākyas*, in which nine anomalistic months equal 248 days, to determine easily the lunar longitude at nine equally distant times in one day. A Malayālam commentary was written on the Veṇvāroha by Acyuta Piṣāraṭi[250] in the early seventeenth century. On the computation of the longitudes of the planets Mādhava wrote a Madhyamānayanaprakāra and an Agaṇitagrahacāra, the latter apparently in 1418. He also composed a Lagnaprakaraṇa on computing the ascendant. None of these has yet been published.

Mādhava's most distinguished pupil was that Parameśvara of Aśvatthagrāma in Kerala whom we have already encountered as a commentator on Āryabhaṭa's A; on Bhāskara's MB and LB (the latter in 1408); on the SS in 1432; on Govindasvāmin's Mahābhāskarīyabhāṣya in 1432; and on Muñjāla's LM in 1409. He made a series of observations of eclipses of the Sun and the Moon between 1393 and 1432.[251] These should have influenced his Grahaṇamaṇḍana,[252]

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[245] CESS A 1, 43b—44a.

[246] CESS A 4. A colection of short texts produced by Mādhava's school was edited by K. V. Sarma under the litle Gaṇitayuktayaḥ as PUIS 24, Hoshiarpur 1979.

[247] Edited by K. V. Sarma, VIS 62, Hoshiarpur 1973.

[248] Edited with the Malayālam *ṭīkā* of Acyuta Piṣāraṭi by K. V. Sarma, RSG 7, Tripunithura 1956.

[249] Edited by K. V. Sarma as appendices to his editions of the Sphuṭacandrāpti and to the Veṇvāroha.

[250] CESS A 1, 36b—38b; A 2, 11a; and A 4.

[251] At the end of *adhyāya* 5 of his Siddhāntadīpikā; see D. Pingree in JAOS 87 (1967), 337—339.

[252] The two recensions were edited by K. V. Sarma, VIS 34, Hoshiarpur 1965.

whose epoch is 15 July 1411; his Grahaṇanyāyadīpikā;[253] and his Grahaṇāṣṭaka.[254] Such an influence, however, is not clearly discernible. Parameśvara's main importance in planetary astronomy in south India was through his *dṛggaṇita* system, expounded in the Dṛggaṇita[255] of 1431. In this the mean motions (with slight modifications in the cases of the lunar *mandocca* and node) were taken from the Saurapakṣa, though the mean planets were assumed not all to be at Aries 0° at the beginning of the Kaliyuga; the longitudes of the *mandoccas* (except for Saturn's) are derived from Muñjāla's LM; and the dimensions of the *manda* and *śīghra* epicycles are new. Parameśvara also wrote two Goladīpikās in which he discusses general astronomical and geographical theories; the first[256] of these was written in 1443 and is accompanied by a commentary composed by the author himself, the second[257] was composed toward the end of his life, probably in the 1450's.

A student of Parameśvara's son and student, Dāmodara, was Gārgyakerala Nīlakaṇṭha Somayājin, one of the commentators on Āryabhaṭa's A. Nīlakaṇṭha was born on about 14 June 1444 at Kuṇḍapura near Tirur in Kerala; in the Āryabhaṭīyabhāṣya (on Kālakriyā 12–15) he refers to his observation of solar eclipses in 1467 and 1501. Nīlakaṇṭha made several efforts to establish new parameters for the mean motions of the planets (most of his parameters for the other elements of the planetary models are taken from the Āryapakṣa or the Saurapakṣa). The first set of new parameters is found in the Tantrasaṅgraha[258] composed in 1501, and in abbreviated form in the Golasāra;[259] the commentaries on the Tantrasaṅgraha—the Yuktidīpikā and the Laghuvṛtti, both written by Nīlakaṇṭha's student, Śaṅkara, in about 1550—are important for the transmission of Mādhava's work on power series. The second set is presented in the Siddhāntadarpaṇa,[260] on which Nīlakaṇṭha composed his own commentary. Nīlakaṇṭha also wrote a small work, the Candracchāyāgaṇita,[261] on computing the Moon's shadow; it also is accompanied by a commentary from the author's own hand. But his most fascinating work, and one that is apparently unique in the history of Indian astronomy, is the Jyotirmīmāṃsā[262] that he wrote in 1504. In this treatise Nīlakaṇṭha vigorously defends the necessity

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[253] Edited by K. V. Sarma, VIS 35, Hoshiarpur 1966.

[254] K. V. Sarma, "The Grahaṇāṣṭaka of Parameśvara. A Short Manual on Eclipses: Edition and Translation," JOR Madras 28 (1958–59), 47–60.

[255] Edited by K. V. Sarma, VIS 30, Hoshiarpur 1963.

[256] Edited with Parameśvara's own *vivṛti* by K. V. Sarma, ALPS 32, Madras 1957.

[257] Edited by T. Ganapati Śāstrī, TSS 49, Trivandrum 1916.

[258] Edited with the Laghuvṛtti of Śaṅkara by S. K. Pillai, TSS 188, Trivandrum 1958; and with the Yuktidīpikā as well as Śaṅkara's Laghuvṛtti by K. V. Sarma, Hoshiarpur 1977.

[259] Edited by K. V. Sarma, VIS 47, Hoshiarpur 1970.

[260] Edited by K.V. Sarma, ALPS 30, Madras 1956; and re-edited with Nīlakaṇṭha's own *ṭīkā* by the same scholar, PUIS 7, Hoshiarpur 1976.

[261] Edited with Nīlakaṇṭha's own *ṭīkā* by K. V. Sarma, PUIS 6, Hoshiarpur 1976.

[262] Edited by K. V. Sarma, PUIS 11, Hoshiarpur 1977.

constantly to correct astronomical parameters on the basis of observation, especially with regard to eclipses, but also with regard to the planets other than the Sun and the Moon; this defense is clearly aimed at the efforts in this direction made not only by Nīlakaṇṭha himself, but also by his *paramaguru*, Parameśvara.

Another pupil of Parameśvara's son, Dāmodara, was the famous author of the Malayālam Yuktibhāṣā, Jyeṣṭhadeva;[263] and among his pupils was Acyuta Piṣāraṭi of Kuṇḍapura in Kerala, the author of the Malayālam commentary on Mādhava's Veṇvāroha whom we have previously mentioned. Acyuta, who died on 7 July 1621 at the age of about seventy, was a prolific author on astronomy. On planetary theory, eclipses, and the *pātas* of the Sun and the Moon he wrote before 1596 a Karaṇottama with a *vivaraṇa*.[264] His Sphuṭanirṇayatantra[265] deals not only with the computation of the positions of the planets, but also with the constellations and with the celestial and terrestrial spheres; on this also Acyuta wrote his own commentary. On eclipses he composed in 1593 an Uparāgakriyākrama (a work of the same title was written by a contemporary Kerala astronomer, Nārāyaṇa,[266]) and an Uparāgaviṃśati,[267] and on the Moon's shadow a Chāyāṣṭaka,[268] which attempts to compress the material expressed by Nīlakaṇṭha in thirty-two verses in the Candracchāyāgaṇita into the compass of a poem of a quarter of that length. But Acyuta's most unusual work is the Rāśigolasphuṭānīti[269] in which he expounds a method for reducing the Moon's longitude in its orbit to an ecliptic longitude in accordance with an Islamic tradition initiated by Yaḥyā ibn Abī Manṣūr in the 820's.[270]

More than a century after Acyuta's death (if the interpretation of his *ahargaṇa* as ca. 22 March 1733 is correct) a Somayājin belonging to the Putumana family (Nūtanagṛha) of Śivapura in Kerala wrote a Karaṇapaddhati,[271] which discusses the basis for many astronomical and mathematical parameters and computations, including Mādhava's power series and their developments. This Putumana wrote several other astronomical works also, of which the most important is the Nyāyaratna; none of these has been published. This tradition of astronomy in Kerala continued well into the nineteenth century, but the author of the Karaṇapaddhati is the last major figure.

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[263] CESS A 3, 76b—77a, and A 4.

[264] Both edited by K. R. Pillai, TSS 213, Trivandrum 1964.

[265] Edited with the author's *vivaraṇa* by K. V. Sarma, PUIS 3, Hoshiarpur 1974.

[266] CESS A 3, 150b—151a, and A 4.

[267] Edited with a Malayālam commentary by Rama Varma Maru Tampurān, RSG 5, Tripunithura [1954].

[268] Edited by K. V. Sarma in his edition of the Sphuṭanirṇayatantra, pp. 69—71.

[269] Edited by K. V. Sarma, "The Rāśigolasphuṭānīti of Acyuta," Brahmavidyā 18 (1954), 306—335; rev. ed. as PUIS 8, Hoshiarpur 1977.

[270] D. Pingree in JHAS 2 (1978), 319.

[271] Edited by K. Sambasiva Sastri, TSS 126, Trivandrum 1937; by P. K. Koru, Cherp 1953; and, with two Malayālam *ṭīkās*, by S. K. Nayar, Madras GOS 98, Madras 1956.

Yantra

The earliest observational instrument in use in India was the *śaṅku* or gnomon, employed to find the cardinal directions in the Śulbasūtras. Since the fourth century B.C. both the *śaṅku* and the *nāḍikā* or outflowing water-clock have been used (with linear zig-zag functions) to determine time within the solar year and within any period of daylight. More elaborate uses of the *śaṅku* as an instrument for measuring local time and terrestrial latitude are given in every *siddhānta* and *karaṇa* in the chapter on *tripraśna;* eventually the noon equinoctial shadow cast by the *śaṅku* was used to characterize the latitude of localities mentioned in late medieval geographical lists.[272]

Besides the simple *śaṅku* vertical to the plane of the horizon, Varāhamihira (PS 14)[273] describes a hemispherical sun dial, a perforated ring, and a perforated sphere (in each of the last two instruments perforations 180° apart serve as a diopter). Other instruments mentioned in the *siddhāntas* are basically illustrative, or are elaborate toys; illustrative are the rotating wooden model of the celestial sphere mentioned by Āryabhaṭa (A. Gola 22–23) or the three-dimensional scale models of the Sines of the planets' azimuths and altitudes described also by the same astronomer,[274] while his clepsydras in fanciful shapes are examples of toys.[275] Many later authors of *siddhāntas* describe these or similar instruments, sometimes in the middle of the text (e.g., MB 3, 56–50), but more often in separate chapters on *yantras* (e.g., BSS 22; ŚDV II 8; SŚŚ 19; and SŚB II 11). The most significant new instrument introduced in these texts composed before the introduction of the astrolabe into India seems to be the *phalaka* or board of Bhāskara (SŚB II, 16–27), which is basically a dial with a gnomon suspended vertically in the plane of the Sun's altitude circle.

The first text to describe the construction and use of the *yantrarāja* or astrolabe in Sanskrit was the Yantrarāja[276] composed by Mahendra Sūri,[277] a Jaina from Bhṛgupura, for Fīrūz Shāh in 1370. A commentary was composed by Mahendra's pupil, Malayendu Sūri,[278] in about 1382, and another, the Vilāsavatī, by Gopirāja[279] in 1540. Mahendra has taken from an unidentified Arabic source not only the rules relating directly to the construction and use of the astrolabe (including a Ptolemaic star-catalogue adjusted for precession), but also a Sine table in which R = 3600 or 1, 0, 0 sexagesimally; a declination

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[272] SATIUS 73a–75b and SATE 53–55.

[273] See also Āryabhaṭa in K. S. Shukla in Gaṇita 18 (1967), 97–100, and in IJHS 12 (1977), 185.

[274] IJHS 12 (1977), 183–184.

[275] Gaṇita 18 (1967), 100–101, and IJHS 12 (1977), 185–186.

[276] Edited with the *ṭīkā* of Malayendu by S. Dvivedin and L. Sarma, Benares 1882, and by K. K. Raikva, Mumbayī 1936.

[277] CESS A 4.

[278] CESS A 4.

[279] CESS A 2, 133a–133b; cf. Gopinātha in CESS A 2, 132b.

table in which $\varepsilon = 23;35°$; a list of cities (including a number in Islamic lands outside of India) with their latitudes expressed in degrees; and shadow tables for twelve and seven digit gnomons.

After Mahendra a number of other texts describing traditional Indian instruments were composed in Sanskrit, almost all of them in Gujarāt and Rājasthān, but the astrolabe was generally neglected. The earliest of these is the Yantraratnāvalī composed in about 1400 by Padmanābha, whom we have mentioned earlier as the author of a commentary of Brahmagupta's Kh. The Yantraratnāvalī contains two chapters, each of which describes the construction and use of a single instrument. The first, on the *diksādhana*, is not available to me, but I have been able to consult a manuscript of the second, the *dhruvabhramaṇa*,[280] on which Padmanābha himself wrote a commentary. This instrument appears to be an elaboration of Bhāskara's *phalaka*, and is not derived from the Islamic tradition.

A treatise describing a semicircular instrument also derived from the native Indian tradition is the Yantracintāmaṇi[281] composed by Cakradhara,[282] probably in the late fifteenth or early sixteenth century; Cakradhara himself wrote a commentary on this, as did also Rāma (Yantradīpikā) in 1625. In the same Indian tradition are the works on *yantras* composed in the sixteenth century by Gaṇeśa, the author of the GL, at Nandigrāma in Gujarāt; these are the Cābukayantra, of which no copy is available to me, and the Pratodayantra,[283] which is a special form of Sun dial.

Interest in the astrolabe was reawakened in north India in the Mughal period. The Risālat al-usṭurlāb of the great thirteenth century Persian polymath, Naṣīr al-Dīn Muḥammad al-Ṭūsī,[284] was translated into Sanskrit at some time during this period. In 1615 at Jambūsara in Gujarāt Viśrāma wrote a Yantracintāmaṇi[285] in which he describes the astrolabe, the gnomon, the waterclock, the quadrant, and several other instruments. Incidentally, he presents several elements borrowed from Islamic astronomy in addition to the astrolabe: tables of the Sine and Cosine functions at intervals of 1° with $R = 120$; a declination table with $\varepsilon = 23;35°$; and the goal year periods of the planets.[286]

A more significant adaptation of Islamic instruments was that by Savāī Jayasiṃha in the 1720's and 1730's, the Mahārāja and founder of Jayapura

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[280] BM Add. 14,365 l.

[281] I have used BM Add. 14,365k and Bodleian Library, CS d.751 (5) and d.774 (3); I have not seen the editions with Cakradhara's own *vivṛti* and Rāma's Yantradīpikā by B. Sarman, Benares 1883, nor that with Hindī and Saṃskṛta *ṭīkās* by S. Śarman, Mathurā 1898.

[282] CESS A3, 36b—37b, and A4.

[283] I have used ff. 15—16 of IO 1989.

[284] CESS A3, 145a, and A4.

[285] Edited by K. K. Raikva on pp. 83—117 of his edition of Mahendra's Yantrarāja.

[286] D. Pingree in JHAS 2 (1978), 319—320.

whom we have previously mentioned as the author of a *koṣṭhaka*. His monumental stone observatories erected at Jayapura, Ujjayinī, Delhi, Mathurā, and Vārāṇasī in imitation of Ulugh Beg's at Samarqand have often been described, though first by his learned *paṇḍita*, Jagannātha.[287] He also wrote a prose treatise on the construction and use of the astrolabe, the Yantrarājaracanā;[288] there is a versification of this, the Yantraprabhā[289] of Śrīnātha. Though a number of Sanskrit astrolabes made in north India in the eighteenth and nineteenth centuries survive, the only other extant Sanskrit texts on instruments written after 1500 are the *yantrādhyāyas* of the SSJ (II 5), the SR (II 3), and the SSBM (II 2). The topic of the development of Indian astronomical instruments is one worthy of much fuller scholarly investigation than has hitherto been devoted to it.

Miśraka

In this section I intend to discuss briefly some minor Sanskrit texts on astronomy that do not fall into any of the normal categories. Most of these deal with one or several aspects of solar and lunar theory, and are related directly or indirectly to the production of *pañcāṅgas* or calendars.

The earliest of these texts is the Dhīkoṭida[290] composed by Śrīpati, the author of the Siddhāntaśekhara, in 1039; in it are succinctly described the computations of lunar and solar eclipses. There are commentaries written by Dinakara[291] in 1608 and by Harikṛṣṇa in ca. 1715.

A younger contemporary of Śrīpati was Daśabala,[292] a Buddhist who composed a Cintāmaṇisāraṇikā[293] in 1055 during the reign of the Paramāra Bhoja. This treatise deals with the various elements—*tithis*, *nakṣatras*, *yogas*, etc.—of a *pañcāṅga*. A commentary was written by Mahādeva[294] in 1258.

Several centuries later, in 1522, Gaṇeśa, the author of the GL, wrote a brief Pātasādhana[295] accompanied by tables that allow one to compute the times of

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[287] See his Yantrādhyāya in R. S. Sharma's edition of the Siddhāntasamrāṭ, vol. 2, pp. 1031—1048.

[288] Edited by Kedarnath, "Śrīmanmahārājādhirājaśrījayasiṃhaviracitā Yantrarājakārikā," The Pandit (Jaipur) 1, 1924, art. 2, with, as art. 3, the English translation published originally by A. H. Garrett and C. Guleri in their The Jaipur Observatory and its Builder, Allahabad 1902; and edited with the Yantraprabhā of Śrīnātha by Kedāranātha, RPG 5, Jayapura 1953.

[289] Edited by Kedāranātha on pp. 17—19 of his edition of the Yantrarājaracanā.

[290] Edited by N. K. Mazumdar, "Dhīkoṭikaraṇa of Śrīpati," Calcutta Oriental Journal 1 (1934), 286—299, and by K. S. Shukla, Lucknow 1969.

[291] CESS A 3, 102a.

[292] CESS A 3, 96b—97a.

[293] Edited by D. D. Kosambi, "The Cintāmaṇisāraṇikā of Daśabala," JOR Madras 19 (1952) suppl.

[294] CESS A 4.

[295] I have used University of Pennsylvania 657 and 697.

occurrence of the two *pātas* of the Sun and the Moon, *vaidhṛta* and *vyatīpāta*. Commentaries on the Pātasādhana were composed by the Divākara who also commented on the Makaranda in the early seventeenth century, by Divākara's cousin, Viśvanātha, and by Dinakara[296] at Poona in 1839.

A work on solar and lunar eclipses, the Parvadvayasādhana,[297] was written by Mallāri[298] in about 1588; this makes plausible his identification with the commentator on Gaṇeśa's GL. To a large extent the Parvadvayasādhana consists of versified tables of variables necessary for the computation of the phases, durations, and magnitudes of eclipses. Commentaries were composed on it by Viśvanātha in the early seventeenth century, and by Kṛṣṇanātha Dvivedin[299] at Vārāṇasī in 1787.[300]

In about 1600 one Bābā,[301] the son of Rāma and the younger brother of Śiva, wrote a Pañcāṅgasiddhi[302] in which he gives annual increments for *tithis*, *nakṣatras*, *yogas*, and the week-days on which sidereal years begin for a period of 90 years.

Viṣṇusiṃha wrote in Nepāla a work on solar and lunar computations, entitled Siddhāntasāra, of which parts survive in both Sanskrit and Nevārī;[303] its epoch is Friday 19 March 1624. The same manuscript contains the chapters on solar and lunar eclipses from his Jyotiḥsāraṅga.

Perhaps the most interesting of these miscellaneous works is the Bhaṅgīvibhaṅgīkaraṇa[304] composed by Raṅganātha at Kāśī in about 1650 in defense of his brother, Munīśvara's, SSBM. In this brief treatise Raṅganātha discusses in detail planetary models and computations, with critical comments on various aspects of the theories of the Paitāmahasiddhānta, Brahmagupta, the Sūryasiddhānta, Bhāskara's SŚB, the Romasasiddhānta, the Vasiṣṭhasiddhānta, the Somasiddhānta, Jñānarāja, the Yavanas, and Lakṣmīdāsa's and Nṛsiṃha's commentaries on the SŚB.

Finally, in this section mention should be made of the Grahalāghavacandrārkī[305] composed by Prajārāma[306] in Gujarāt in 1738. This work gives rules for computing the positions of the Sun and the Moon according to the Gaṇeśapakṣa without resorting to tables.

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296 CESS A 3, 105b—106a.
297 I have used Oxford, CS d. 751 (10).
298 CESS A 4.
299 CESS A 4.
300 I have used Oxford, CS e. 149 (10).
301 CESS A 4.
302 I have used University of Pennsylvania 1800.
303 I have used IO 3283f.
304 Edited by M. H. Ojhā, Vārāṇasī 1959.
305 I have used Baroda 3113.
306 CESS A 4.

Chapter III

MATHEMATICS

Mathematics[1] is useful to a number of *śāstras* in India as elsewhere—the *śulbasūtras*, astronomy, and astrology, which are discussed in this volume, as well as such subjects as alchemy, medicine, prosody, and philosophy (particularly Jaina). But there also exists a literature directly concerned with mathematics, in particular with arithmetic (especially its commercial and other practical applications), algebra, and geometry. There was never in India a *jāti* of mathematicians, and rarely anything that could be called a school; most mathematicians were *jyotiṣīs* (astronomers or astrologers). Therefore, the mathematical literature consists either in the form of chapters of astronomical *siddhāntas* or of treatises composed, with a few exceptions, by scholars who were also authors of astronomical texts. Moreover, several important branches of Indian mathematics—analemmata and trigonometry, for instance—rarely if ever are treated outside of the astronomical context that endowed them with significance.

Gaṇita

The earliest text of this genre that we have is the first chapter of Āryabhaṭa's A entitled Gaṇitapāda.[2] In thirty-two verses he deals succinctly with a number of selected topics: the decimal place-value system of numbers; squares and cubes; square-roots and cube-roots; the areas of triangles, rectangles, trapezia, and circles, and the volume of a pyramid;[3] chords and sines of arcs of a circle; π;

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[1] Among general works on Indian mathematics, the most useful are: B. Datta and A. N. Singh, History of Hindu Mathematics, 2 vols., Lahore 1935—1938, reprinted Bombay 1962 (not always reliable); C. N. Srinivasiengar, The History of Ancient Indian Mathematics, Calcutta 1967; T. A. Sarasvati Amma, Geometry in Ancient and Medieval India, Delhi 1979; and A. K. Bag, Mathematics in Ancient and Medieval India, Varanasi 1979.

[2] The most recent treatment of the Gaṇitapāda is K. Elfering, Die Mathematik des Āryabhaṭa I, München 1975; see also R. C. Gupta, "On Some Mathematical Rules from the Āryabhaṭīya," IJHS 12 (1977), 200—206; and A. Volodarsky, "Mathematical Achievements of Āryabhaṭa," ibid., 167—172.

[3] K. Elfering, "The Area of a Triangle and the Volume of a Pyramid as well as the Area of a Circle and the Surface of the Hemisphere in the Mathematics of Āryabhaṭa I," IJHS 12 (1977), 232—236.

shadow-problems; intersecting circles; sums of various series;[4] solutions to quadratic equations; proportions; and the solution of indeterminate equations of the first degree.[5] Thus he includes in this chapter on *gaṇita* not only arithmetic, geometry, and algebra, but several topics of primary interest to astronomers—i.e., trigonometry, intersecting circles (for eclipse calculations), and indeterminate equations (for deriving the numbers of rotations of the planets in a Mahāyuga). The solution to the indeterminate equations utilizes continued fractions; continued fractions had been investigated by Euclid, though not applied to the problem of indeterminate equations, so far as we know, by the Greeks. Many useful illustrations to Āryabhaṭa's rules were given by his early commentator, Bhāskara.[6]

This same Bhāskara, in his MB (1, 41), appears to be the first to name the continued fraction method of solving indeterminate equations the "pulverizer" *(kuṭṭakāra);* he applies the "pulverizer" to problems of the planets' mean motions in MB 1, 41–52. In MB 8, 7–25 he sets the student various mathematical problems that arise in astronomy, most of which are intended to exercise his facility in applying the "pulverizer."

Bhāskara's contemporary, Brahmagupta, devotes two *adhyāyas* of his BSS to mathematics. Chapter 12[7] is the earliest extant formal treatise on arithmetic in Sanskrit. In it he gives succinct rules for twenty arithmetical operations *(parikarma)* and eight determinations *(vyavahāra)*. These are listed by Pṛthūdakasvāmin; the *parikarmāṇi* are: addition *(saṅkalita)*, subtraction *(vyavakalita)*, multiplication *(pratyutpanna)*, division *(bhāgahāra)*, square *(varga)*, square-root *(vargamūla)*, cube *(ghana)*, cube-root *(ghanamūla)*, five[8] rules for operating with fractions *(pañcajātayaḥ)*, the rule of three *(trairāśika)*, the inverse rule of three *(vyastatrairāśika)*, the rules of five, seven, nine, and eleven terms, and barter *(bhāṇḍapratibhāṇḍa)*, while the *vyavahārāḥ* are: mixtures *(miśraka)*, series *(śreḍhī)*, plane geometry *(kṣetra)*, (solid geometry, subdivided into) excavations *(khāta)*, stacks *(citi)*, sawn lumber *(krākacika)*, and mounds of grain *(rāśi)*, and shadow-problems *(chāyā)*. Of special interest

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[4] On the history of series in India see also G. Chakravarti, "Growth and Development of Progressive Series in India," JDL/UC 24 (1934), art. 6; and T. A. Sarasvati, "Śreḍhīkṣetras or Diagrammatical Representations of Mathematical Series," JOR Madras 28 (1958–59), 74–85, and "The Development of Mathematical Series in India after Bhāskara II," BNISI 21 (1963), 320–343.

[5] A. K. Bag, "The Method of Integral Solution of Indeterminate Equations of the Type: $BY = AX \pm C$ in Ancient and Medieval India," IJHS 12 (1977), 1–16.

[6] K. S. Shukla, "Hindu Mathematics in the Seventh Century as Found in Bhāskara I's Commentary on the Āryabhaṭīya, Gaṇita 22 (1971), 1, 115–130, and 2, 61–78; and 23 (1972), 1, 57–79, and 2, 41–50.

[7] Translated with excerpts from Pṛthūdakasvāmin's commentary by H. T. Colebrooke, Algebra with Arithmetic and Mensuration from the Sanscrit, London 1817, repr. Walluf bei Wiesbaden 1973, pp. 277–324.

[8] Five only are given by Brahmagupta; a sixth is said by Pṛthūdaka to have been described by Skandasena.

is his exhaustive investigation of triangles and quadrilaterals—mostly right triangles and cyclic quadrilaterals (BSS 12, 21—39). Chapter 18 is devoted to algebra, here denominated *kuṭṭaka* after the pulverizer;[9] it is illustrated by exemplary problems *(udāharaṇa)*. Among the topics discussed, in addition to the pulverizer itself, are the mathematics of zero and of surds, quadratic equations, equations with several unknowns, and indeterminate equations of the second degree *(vargaprakṛti)*. Brahmagupta's method for solving *vargaprakṛti* equations is not universally applicable. There is no convincing evidence to support the theory that Brahmagupta had a Greek source.[10]

Śrīdhara evidently wrote his four works on mathematics between the time of Brahmagupta, whom he gently criticizes without naming,[11] and before Govindasvāmin, who quotes a verse from Śrīdhara's Triśatikā in the Prakaṭārthadīpikā that he wrote in ca. 850.[12] Thus Śrīdhara flourished most probably in the eighth century. Though his work on algebra that was known to Bhāskara[13] is now lost, there still survive three of his writings on arithmetic; all seem to be epitomes of a longer, lost work entitled Pāṭīgaṇita, Bṛhatpāṭī, or Navaśatī.[14] The first of the three works is the incomplete Pāṭīgaṇita,[15] of which we have some 251 verses (118 are *sūtras* in *āryā* meter, and 133 are *udāharaṇāni* mostly in *āryā*). Following BSS 12 it divides arithmetic into *parikarmāṇi* (Śrīdhara adds nine to Brahmagupta's twenty) and *vyavahārāḥ* (Śrīdhara adds the mathematics of zero, which was treated in BSS 18, to Brahmagupta's eight). The work begins with verses on mensuration *(paribhāṣā)*. Unfortunately, the unique manuscript breaks off in the middle of the third *vyavahāra (kṣetra)*. Sharing many verses with this Pāṭīgaṇita is the Pāṭīgaṇitasāra or Triśatikā.[16] Despite its second title, this work contains only

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[9] A rearrangement of this chapter with excerpts from an anonymous commentary as found in an India Office Library manuscript, 596 A, was translated by COLEBROOKE, ibid., pp. 325—378.

[10] Most recently supported by B. L. VAN DER WAERDEN, "Pell's Equation in Greek and Hindu Mathematics," Russian Mathematical Surveys 31: 5 (1976), 210—225.

[11] K. S. SHUKLA, The Patiganita of Sridharacarya, Lucknow 1959, pp. xix—xx.

[12] On *uttarabhāga* 14, 97 of Parāśara's Horāśāstra.

[13] Bījagaṇita 116 and *granthasamāpti* 2; in the latter verse Bhāskara also names as his predecessors Brahma(gupta) and Padmanābha.

[14] In Śrīdhara's works occur the earliest instances of the technical term *pāṭī* for arithmetic. Various authors have claimed that it refers to the calculating board (see, e.g., B. DATTA, "The Science of Calculation by the Board," AMM 35 (1928), 520—529), though others, with good reason, have questioned this meaning (e.g., R. VENKATACHALAM IYER, "Pāṭīgaṇita and the Hindu Abacus," MS 18 (1950), 79—82).

[15] Edited with an anonymous commentary and an English translation by K. S. SHUKLA, Lucknow 1959. There is a Russian translation and commentary by A. VOLODARSKII (and O. F. VOLKOVOI) in Fiziko-matematičeskie Nauki v Stranakh Vostoka, Moskva 1966, pp. 141—246.

[16] Edited by S. DVIVEDIN, Benares 1899; partial English translation by N. RAMANUJACHARIA and G. R. KAYE, BM 3, 13 (1912—13), 203—217.

some 180 *āryā* verses, of which 73 are *sūtras* and 107 *udāharaṇāni*. It follows the order of the Pāṭīgaṇita and thereby provides some idea of the contents of *vyavahārāḥ* 4—8; but it fails to discuss the mathematics of zero. The third of Śrīdhara's works is entitled Gaṇitapañcaviṃśī, of which a fragment of two folia has recently been discovered.[17] Of this work, written almost exclusively in *ślokas*, there survive 53 verses, of which 20 are *udāharaṇāni;* the section between the inverse rule of three *(vyastatrairāśika)* and the discussion of quadrilaterals in the section on plane geometry *(kṣetra)* is missing.

Perhaps contemporary with Śrīdhara is the work on mathematics preserved in the Bakhshālī manuscript;[18] though some scholars would date it as early as 200 A.D. on the basis of its symbols, its language, its meter, and its references, none of their arguments is very persuasive. The work is earlier than the manuscript, which is written in "early" Śāradā and may therefore have been copied in the eighth, ninth, or tenth century. Arguments based on its relation to extant Sanskrit texts on *gaṇita* appear to me rather unreliable since we have so little from an early period to compare it with, and since it is clearly not in the main tradition of these texts. However, the fact that it is composed of *sūtrāṇi* and *udāharaṇāni* in verse with symbolic statements and prose solutions of the examples as are the works of Śrīdhara makes me believe that it follows the same model as does he. Aside from Āryabhaṭa and Brahmagupta, who did not follow this model, the only mathematicians earlier than Śrīdhara that we know of are Maskari, Pūraṇa, Pūtana, and Mudgala whom the earlier Bhāskara mentions,[19] and Nārmada whom Śrīdhara himself mentions,[20] while Lalla was probably contemporary with Śrīdhara.[21] The tradition, then, of works on *gaṇita* based on the classification into *parikarmāṇi* and *vyavahārāḥ* (the latter are specifically ascribed to Maskari, Pūraṇa, and Mudgala by Bhāskara) was not a very long one; the treatment of rules and examples offered by Śrīdhara and the Bakhshālī manuscript was probably even shorter, though no certain *terminus post quem* can be attached to it. The subjects treated in the Bakhshālī manuscript include the rule of three, series, square-roots, mixtures *(miśraka)*, simultaneous equations, and quadratic equations; presumably the rest of the traditional contents of a work on *gaṇita* once were present when the manuscript was complete.

The earliest influence of Indian mathematics upon Islam presumably was contemporaneous with the earliest translations of Sanskrit astronomical texts

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[17] I have used ff. 1 and 3 of G. 111f. in the Wellcome Institute for the History of Medicine.

[18] Edited by G. R. Kaye as ASI, NIS 43, 2 vols., Calcutta 1927—1933. See also, against Kaye, B. Datta, "The Bakhshālī Mathematics," BCMS 21 (1929), 1—60, and A. A. Krishnaswami Ayyangar, "The Bakshālī Manuscript," MS 7 (1939), 1—16.

[19] Maskari, Pūraṇa, and Mudgala on A Daśagītikā 1 (pp. 6—7 Shukla); and Maskari, Pūraṇa, and Pūtana on A Gaṇita 9 (p. 67 Shukla).

[20] Gaṇitapañcaviṃśī, sūtra 23.

[21] Shukla, Pāṭīgaṇita, p. ix.

into Arabic in the eighth century. The first concrete evidence that survives for that transmission is the work on performing arithmetical operations with the ten Indian number symbols written by al-Khwārizmī, probably at Baghdād, in the early ninth century; this is preserved in several recensions of a Latin translation of the early twelfth century.[22] A large group of Arabic arithmetics characterized by the use of the Indian number symbols (for both integers and fractions) and the dust board *(takht)* were denominated *al-ḥisāb al-hindī* ("Indian calculation") by their authors. The oldest of these is the Kitāb al-fuṣūl fī al-ḥisāb al-hindī, composed by al-Uqlīdisī at Damascus in 952/3.[23] The precise relationship of such mathematical works to Indian texts on *gaṇita* is not as yet established.

Mahāvīra,[24] the most famous of the Jaina mathematicians, wrote his Gaṇitasārasaṅgraha[25] during the reign of the Rāṣṭrakūṭa Amoghavarṣa, who ruled parts of Karṇāṭaka and Mahārāṣṭra between ca. 814/15 and ca. 880. In this work he has divided the traditional contents of *gaṇitaśāstra* into an opening *saṃjñādhikāra* (*paribhāṣā*, mathematics of zero, and addition and subtraction) and eight *vyavahāras*. The *parikarma* is concerned with multiplication, division, squares, square-roots, cubes, cube-roots, and series; the *kalāsavarṇa* and *prakīrṇaka* with fractions; the *trairāśika* with the rules of three, five, seven, and nine; the *miśraka* with mixtures, the pulverizer, and sums of series; the *kṣetragaṇita* with plane geometry;[26] the *khāta* with solid geometry; and the *chāyā* with shadow problems. The GSS was commented on in Kannaḍa by Daivajñavallabha[27] (Bālabodha) and in Sanskrit by Varadarāja. Furthermore, it was translated into Telugu by Pāvulūri Mallana[28] in the eleventh century and into Rājasthānī by Amīcandra[29] in about 1850.

The second Āryabhaṭa included two chapters on mathematics in the MS that he wrote in about 950—1000. *Adhyāya* 15, the *pāṭyadhyāya*, deals with

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[22] A facsimile of the unique manuscript of the earliest of these versions with an inaccurate transcription is given by K. Vogel, Mohammed ibn Musa Alchwarizmi's Algorismus, Aalen 1963.

[23] A. S. Saidan, The Arithmetic of al-Uqlīdisī, Dordrecht—Boston 1978. Further information on the Indian influence on Islamic arithmetic will be found in H. Hermelink, "Arabic Recreational Mathematics as a Mirror of Age-old Cultural Relations between Eastern and Western Civilizations," Proceedings of the First International Symposium for the History of Arabic Science, vol. 2, Aleppo 1978, pp. 44—54.

[24] CESS A 4.

[25] Edited with an English translation by M. Raṅgācārya, Madras 1912; and with a Hindī version by L. Jaina as JJG 12, Solāpura 1963.

[26] B. Datta, "On Mahāvīra's Solution of Rational Triangles and Quadrilaterals," BCMS 20 (1930), 267—294; E. T. Bell, "Mahavira's Diophantine System," BCMS 38 (1946), 121—122; and R. C. Gupta, "Mahāvīrācārya on the Perimeter and Area of an Ellipse," ME 8, 1 (1974), B 17—19, and "Mahāvīrācārya's Rule for the Surface-area of a Spherical Segment," Tulasī prajñā 2 (1975), 63—66.

[27] CESS A 4.

[28] CESS A 4.

[29] CESS A 1, 45b—46a; A 2, 13b; and A 4.

the traditional topics of arithmetic and geometry in 120 verses, while *adhyāya* 18, the *kuṭṭakādhyāya*, discusses the pulverizer, of whose use it gives many examples, in 70 verses. This treatment is clearly modelled on the BSS.

More closely based on the same prototype, though of shorter extent, are the two *adhyāyas* devoted to mathematics in the SŚŚ composed by Śrīpati in about 1040: *adhyāya* 13, *vyaktagaṇita*, on *pāṭī* in 55 verses, and *adhyāya* 14, *avyaktagaṇita*, on algebra in 37 verses. Many of the verses of SŚŚ 13 appear as *sūtras* in Śrīpati's Gaṇitatilaka[30] to which many examples (some taken from Śrīdhara) have been added. Unfortunately, however, the Gaṇitatilaka does not survive in its entirety. After a *paribhāṣā* modelled on Mahāvīra's, it proceeds in the normal order, though inserting the mathematics of zero in verse 45, in the middle of its treatment of fractions; this mathematics of zero differs from that in SŚŚ 14, 6. The text breaks off in the middle of the *miśrakavyavahāra*. A commentary on the Gaṇitatilaka was written by Siṃhatilaka Sūri, the pupil of Vibudhacandra; this Siṃhatilaka wrote a *vṛtti* on the Bhuvanadīpaka of Padmaprabha Sūri at Vijāpura in 1269.

Perhaps contemporary with Śrīpati was the mathematician Jayadeva.[31] Though none of his works are now extant, a quotation in the Sundarī composed by Udayadivākara in 1073 proves that he knew the cyclic solution *(cakravāla)* of Pell's equation—that is, of indeterminate equations of the second degree *(vargaprakṛti)* for which Brahmagupta possessed a partial solution. Jayadeva's solution was independently discovered in the West in the seventeenth century.

The second Bhāskara, to whom this *cakravāla* has sometimes been erroneously attributed, wrote two works on mathematics in the middle of the twelfth century. The Līlāvatī,[32] on *pāṭī*, after the usual *paribhāṣā* section on measure-

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[30] Edited with the commentary of Siṃhatilaka Sūri from a single, incomplete manuscript by H. R. KAPADIA as GOS 78, Baroda 1937. The following table illustrates the relationship between SŚŚ 13 and GT:

SŚŚ 13	GT	SŚŚ 13	GT	SŚŚ	GT	SŚŚ	GT
2	15	7	30	14	86	17	111
5	23	9	38	15	97	18	113
6	29	13	83	16	108		

[31] CESS A 3, 60b, and A 4.

[32] The Līlāvatī was published at Calcutta in 1832; edited by TĀRĀNĀTHA ŚARMAN, Kalikātā 1846; published at Calcutta in 1846, 2nd ed. Calcutta 1876; published at Calcutta in 1852; edited with the *vivaraṇa* of Mahīdhara and the Telugu *ṭīkā* of TAḌAKAMALLA VEṄKAṬA KṚṢṆARĀVA by V. RĀMASVĀMIN SĀSTRIN, Madras 1863; edited by JĪVĀNANDA VIDYĀSĀGARA, Calcutta 1876, 4th ed. Calcutta 1909; edited by SUDHĀKARA DVIVEDIN, Benares 1878; edited with his own Sanskrit *ṭīkā* by BĀPŪDEVA ŚĀSTRIN, Benares 1883; edited by BHUVANACANDRA BASAK, Calcutta 1885; as an appendix to BANERJI's edition of COLEBROOK's translation, Calcutta

ment, contains the usual *parikarmas* (adding the mathematics of zero after the discussion of fractions) and *vyavahāras* (adding at the end a section on the pulverizer and one on *aṅkapāśa* or combinations and permutations). This became the standard textbook on arithmetic in India, as is easily seen from the hundreds of manuscript copies, many editions, various translations, and numerous commentaries. For it was translated into Kannaḍa by Rājāditya,[33] who is said to have been a Jaina from Pāvinabāge at the court at Dorasamudra of the Hoysaḷa Ballāla—presumably Ballāla II (1173—1220); into Persian by Abū al-Fayḍ Fayḍī[34] for the Mughal Akbar (1556—1605) in 1587, by Medinīmalla[35] in 1663/4, and by Muḥammad Amīn,[36] who flourished between 1661 and 1678; and into Hindī by Amīcandra at Jayapura in 1842. Commentaries on the Līlāvatī were composed by Parameśvara at Aśvatthagrāma, Kerala, before 1432 *(vivaraṇa);* by Gaṅgādhara[37] at Jambūsaras, Gujarāt, in 1420 (Gaṇitāmṛtasāgarī); by Moṣadeva[38] before 1472; by the Lakṣmīdāsa who commented on the SŚB in 1501; by Sūryadāsa[39] at Pārthapura on the Godāvarī in 1541 (Gaṇitāmṛtakūpikā); by the well known Gaṇeśa at Nandigrāma in 1545 (Buddhivilāsinī); by Nārāyaṇa[40] in Kerala in about 1550 (Karmapradīpikā); by Śaṅkara, but completed by the above mentioned Nārāyaṇa, in Kerala in about 1556 (Kriyākramakarī); by Mahīdhara at Vārāṇasī in 1587; by Munīśvara, the author of the SSBM, at Kāśī in the early seventeenth century (Nisṛṣṭārthadūtī); by his contemporary, Raṅganātha, also at Vārāṇasī

1893, 2nd ed. Calcutta 1927; edited with a Marāṭhī *ṭīkā* by V. P. Khānāpūrkar, Poona 1897; edited with a Hindī *ṭīkā* by R. S. Śarmā, Bombay 1907; edited by Sudhākara Dvivedin as BŚS 39, Benares 1912; edited by Rādhāvallabha, Calcutta 1913; edited with his own Sanskrit *ṭīkā* by Muralīdhara Ṭhākura as HNM 3, Benares 1928, 2nd ed. Benares 1938; edited with the *ṭīkās* of Gaṇeśa and Mahīdhara by D. Āpaṭe as ASS 107, 2 vols., Poona 1937; edited with the *ṭīkā* of Dāmodara Miśra by D. Jhā as MSVG 8, Darbhanga 1959; edited with the Sanskrit and Hindī *ṭīkās* of Laṣaṇa Lāla Jhā by S. Śarman as VSG 62, Benares 1961; edited with his own Sanskrit and Hindī *ṭīkā* by Sītārāma Jhā, 4th ed., Benares 1970; and edited with the *ṭīkā* of Śaṅkara and Nārāyaṇa by K. V. Sarma as VIS 66, Hoshiarpur 1975. An English translation by J. Taylor was published at Bombay in 1816, and another by H. T. Colebrooke in his Algebra, with Arithmetic and Mensuration, London 1817, pp. 1—127; the latter was reprinted by H. C. Banerji, Colebrooke's Translation of the Lílávatí, Calcutta 1893, 2nd ed. Calcutta 1927.

[33] See M. M. Bhat, "Mathematics in Karnataka of the Middle Ages," Bhārata-Kaumudī, vol. 1, Allahabad 1945, pp. 127—136. His Vyavahāraganita in Kannaḍa was edited by M. M. Bhat, Madras 1955.

[34] CESS A 1, 44b.

[35] CESS A 4.

[36] CESS A 4.

[37] CESS A 2, 81a—82a; A 3, 26b; and A 4.

[38] CESS A 4.

[39] K. M. K. Sarma, "The Bhāskara Bhūṣaṇa of Sūrya Paṇḍita", PO 11 (1946), 54—66, and "Siddhānta-saṃhitāsāra-samuccaya of Sūrya Paṇḍita," Siddha-Bhāratī, pt. 2, VIS 2, Hoshiarpur 1950, pp. 222—225.

[40] CESS A 3, 151a, and A 4.

(Mitabhāṣiṇī); by Paraśurāma[41] before 1659; by Rāmakṛṣṇa[42] at Jalapura in the Sahyādri in 1687 (Gaṇitāmṛtalaharī); by Śrīdhara Mahāpātra at Dalapura north of Nīlagiri in Orissa in 1717 (Sarvabodhinī); by Kṛpārāma[43] at Ahmadābād in about 1790; and by Nīlāmbara Jhā,[44] probably at Alavara in Rājasthān where he was the court astrologer in the middle of the nineteenth century. To this impressive list of explicators of the Līlāvatī could be added many more whose dates are uncertain, or whose names are unknown.

Less popular than the Līlāvatī because it is more difficult was Bhāskara's Bījagaṇita.[45] This, the standard Sanskrit textbook on algebra, describes arithmetical operations involving positive and negative numbers and zero; irrational numbers; the pulverizer (virtually identical with the section on this subject in the Līlāvatī); "Pell's equation" (the *vargaprakṛti*); the cyclic solution *(cakravāla)* thereof; various kinds of linear and quadratic equations with one or more unknowns; and equations involving the product of different unknowns *(bhāvita)*. The Bījagaṇita was translated into Persian by 'Aṭa' Allāh Rushdī[46] for the Mughal Shāh Jahān (1628–1659) in 1634/5. It was commented on by Sūryadāsa at Pārthapura in 1538 (Sūryaprakāśa); by Kṛṣṇa[47] at Vārāṇasī in about 1600 (Bījāṅkura = Navāṅkura = Bījapallava = Kalpalatāvatāra); by Bhāskara[48] at Rājagiri in 1652 (Śiśubodhana); by Rāmakṛṣṇa[49] at Jalapura in the Sahyādri in 1687 (Bījaprabodha); by Haridāsa before 1725 (Vāsanā-

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[41] CESS A 4.

[42] P. K. Gode, "Date of Gaṇitāmṛtalaharī of Rāmakṛṣṇa," ABORI 11 (1930), 94–95.

[43] CESS A 2, 48b–49a.

[44] CESS A 3, 193a–195a.

[45] Published Calcutta 1834, rev. ed. Calcutta 1834; published Calcutta 1838 and Calcutta 1846; partial edition with German translation in H. Brockhaus, "Über die Algebra des Bhāskara," BVKSGWL, Phil.-hist. Kl. 4 (1852), 1–46; published Calcutta 1853; edited by G. Pāṭhaka, Benares 1864; edited by Jīvānanda Vidyāsāgara, Calcutta 1878; edited with his own Sanskrit *ṭīkā* by Jīvanātha Jhā, Benares 1885; edited with his own Sanskrit *ṭīkā* by Sudhākara Dvivedin, Benares 1888; edited with a Marāṭhī translation and *ṭīkā* by V. P. Khānāpūrkar, Poona 1913; edited with his own Sanskrit *ṭīkā* by Rādhāvallabha, Calcutta 1917; edited with S. Dvivedin's and his own Sanskrit *ṭīkās* by Muralīdhara Jhā as BSS 40, Benares 1927; edited with the *ṭīkā* of Kṛṣṇa by D. Āpaṭe as ASS 99, Poona 1930; edited with his own Sanskrit and Hindī *ṭīkās* by Durgāprasāda Dvivedin, 3rd ed., Lakṣmaṇapura 1941; edited with J. Jhā's Sanskrit and his own Sanskrit and Hindī *ṭīkās* by Acyutānanda Jhā as KSS 148, Benares 1949; and edited with the *ṭīkā* of Kṛṣṇa by T. V. Rādhākṛṣṇa Śāstrin as TSMS 78, Tanjore 1958. An English translation was published in H. T. Colebrooke, Algebra, with Arithmetic and Mensuration, London 1817, pp. 129–276; the section on the pulverizer was translated in D. M. Mehta, Theory of Simple Continued Fractions, Bhavnagar [1931 ?], pp. 26–71.

[46] CESS A 1, 39b. An English translation of this Persian version by E. Strachey with notes by S. Davis was published at London in 1813.

[47] CESS A 2, 53a–55b, and A 4.

[48] CESS A 4.

[49] P. K. Gode, "Date of Bījaprabodha," ABORI 10 (1929), 160–161.

bhāṣya); by Kṛpārāma at Ahmadābād in 1792 (Bālabodhinī); and by an obscure Nijānanda[50] (Bījālavāla).

After Bhāskara the next major authority on mathematics was Nārāyaṇa,[51] who completed his Gaṇitakaumudī[52] in 1356. The GK contains the traditional *paribhāṣā*, *parikarmas*, and *vyavahāras*, followed by the pulverizer, "Pell's equation," factors,[53] combinations, and magic squares. Before writing the GK Nārāyaṇa had written a work on algebra, the Bījagaṇitāvataṃsa.[54] This work covers arithmetical operations involving positive and negative numbers and zero; irrational numbers; the pulverizer and "Pell's equation" (these two were drawn upon for the corresponding section in the GK); various kinds of linear and quadratic equations with one or more unknowns (the text is not extant beyond the beginning of the section on linear equations); and equations involving the product of different unknowns. Thus it is modeled directly on the BG.

Sometime after Bhāskara one Devarāja[55] composed a Kuṭṭākāraśiromaṇi,[56] on which he wrote his own *ṭīkā*, entitled Mahālakṣmīmuktāvalī. His objective was to expand upon the pulverizer as propounded by Āryabhaṭa. Also subsequent to Bhāskara Rāmacandra wrote a Kautukalīlāvatī.[57] In this work, after the *paribhāṣā*, come problems of plane and solid geometry and estimates of the quantities of various substances in differently shaped containers; involved are, among other things, specific gravities. Traditional mathematics was continued in the sixteenth century by the Bījādhyāya of Jñānarāja, who wrote the SSJ in 1503 and was the father of Sūryadāsa, the commentator on Bhāskara's L and BG; and by the Gaṇitamañjarī of Jñānarāja's great nephew, Gaṇeśa.[58] Neither of these works has been published.

Except for commentaries, no significant traditional Sanskrit works on mathematics were written after the sixteenth century. At Jayasiṃha's court at Jayapura, however, in the 1720's and 1730's, an effort was made to translate Arabic and Persian versions of Greek mathematical treatises into Sanskrit. The two leading translators were Nayanasukhopādhyāya[59] and Jagannātha; the former translated, at the dictation of Muḥammad Ābida, the Σφαιρικά of

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[50] CESS A 3, 173a.

[51] CESS A 3, 156b—157a.

[52] Edited by Padmākara Dvivedin as PWSBT 57, 2 vols., Benares 1936—1942.

[53] See R. C. Gupta, "Nārāyaṇa's Method for Evaluating Quadratic Surds," ME 7 (1973), B 93—96.

[54] The fragment in the Benares manuscript was edited by K. S. Shukla, Lucknow 1970.

[55] CESS A 3, 120b—121a.

[56] Edited with the *ṭīkā* by B. D. Āpaṭe as ASS 125, Poona 1944.

[57] I have used Leipzig 986; Oxford, CS d. 796 (6); and University of Pennsylvania 1861.

[58] CESS A 2, 107a—110a; A 3, 28b; and A 4.

[59] CESS A 3, 132a, and A 4.

Theodosius under the title Ukāra (Arabic Ukarr) or Kaṭara (Arabic *quṭr*), the latter Euclid's Στοιχεῖα under the title Rekhāgaṇita.[60]

Mathematics in astronomy

The mathematics utilized in astronomical texts is most developed in the areas of analemmata and of trigonometry—as well as, of course, the application of the pulverizer to astronomical problems that we have already considered. Some of the most significant mathematical work undertaken in India was in connection with trigonometry.[61] Briefly, after the initial success in constructing tables of Sines and Versines and in inventing a rule for finding the approximate Sine of any angle in the fifth through seventh centuries, the next advance was the discovery by the second Bhāskara of the formula for the addition of Sines. The more advanced trigonometry of the seventeenth and eighteenth century astronomers of northern India seems to be due to the influence of al-Kāshī and Ulugh Beg.

But in Kerala truly extraordinary advances were made by a school of astronomer-mathematicians building on the pioneering work of Mādhava of Saṅgamagrāma in the late fourteenth and early fifteenth century. He evidently discovered what is called "Gregory's Series" for π and the power series for sines and cosines associated with Newton and Leibniz.[62] Mādhava's work was

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[60] Edited by H. Dhruva and K. Trivedin as Bombay SS 61—62, 2 vols., Bombay 1901—1902.

[61] See, for example, A. N. Singh, "Hindu Trigonometry," PBMS, NS 1 (1939), 77—92; and the following articles, among others, by R. C. Gupta: "Early Indians on Second Order Sine Differences," IJHS 7 (1972), 81—86; "Bhāskara I's Approximation to Sine," IJHS 2 (1967), 121—136; "Addition and Subtraction Theorems for the Sine and the Cosine in Medieval India," IJHS 9 (1974), 164—177; "Sine of Eighteen Degrees in India up to the Eighteenth Century," IJHS 11 (1976), 1—10; and "Sines of Submultiple Arcs as found in the Siddhānta-tattvaviveka," RUMJ 5 (1974), 21—27.

[62] After the work of C. M. Whish, "On the Hindú Quadrature of the Circle and the Infinite Series of the Proportion of the Circumference to the Diameter in Four Sástras, the Tantrasangraham, Yucti Bháshá, Carana Paddhati, and Sadratnamálá," TRAS 3 (1830), 509—523, the investigation of this topic was revived by C. T. Rajagopal; see K. M. Marar and C. T. Rajagopal, "On the Hindu Quadrature of the Circle," JBBRAS, NS 20 (1944), 65—82, and "Gregory's Series in the Mathematical Literature of Kerala," MS 13 (1945), 92—98; C. T. Rajagopal and A. Venkataraman, "The Sine and Cosine Power-series in Hindu Mathematics," JRASB/S 15 (1949), 1—13; C. T. Rajagopal, "A Neglected Chapter of Hindu Mathematics," SM 15 (1949), 201—209; C. T. Rajagopal and T. V. V. Aiyar, "In the Hindu Proof of Gregory's Series," SM 17 (1951), 65—74, and "A Hindu Approximation to Pi," SM 18 (1952), 25—30; and C. T. Rajagopal and M. S. Rangachari, "On an Untapped Source of Medieval Keralese Mathematics," AHES 18 (1978), 89—102. His investigations have been continued by T. A. Saraswathi, "The Development of Mathematical Series in India after Bhāskara II," BNISI 21 (1963), 320—343; by

continued by, and is largely known from the works of, Nīlakaṇṭha, Jyeṣṭhadeva, and Śaṅkara in the sixteenth century, and Putumana in the eighteenth.

A. K. Bag, "Trigonometrical Series in the Karaṇapaddhati and the Probable Date of the Text," IJHS 1 (1966), 98—106, and "Mādhava's Sine and Cosine Series," IJHS 11 (1976), 54—57; and by R. C. Gupta, "The Mādhava-Gregory Series," ME 7 (1973), B 67—70, "An Indian Form of Third Order Taylor Series Approximation of the Sine," HM 1 (1974), 287—289, and "Mādhava's and Other Medieval Indian Values of Pi," ME 9 (1975), B 45—48.

Chapter IV

DIVINATION

Omens *(adbhuta, utpāta, nimitta)* have probably always been regarded by Indians, as by others, as a means of knowing the future. There are, for instance, various references in the Ṛgveda (II 42–43 and X 165) and in the Atharvaveda (VI 27–29 and VII 64) to an ominous bird *(śakuna)*. But the earliest attempts[1] to list and classify omens and to provide their ritual countermeasures *(śānti)* occur in the Kauśikasūtra[2] (XIII = *kaṇḍikās* 93–136) of the Atharvaveda and the common source[3] of the Adbhutabrāhmaṇa, which is adhyāya VI or V of the Ṣaḍviṃśabrāhmaṇa,[4] the Āśvalāyanagṛhyapariśiṣṭa[5] (IV 11–22), and the Adbhutaśānti[6] of the Atharvavedapariśiṣṭa. The omens in this latter source were associated with the seven deities Indra, Varuṇa, Yama, Agni, Vaiśravaṇa, Viṣṇu, and Vāyu, and involve phenomena occurring on the earth, in the atmosphere, and in the heavens. One cannot but be struck by the similarity of these omens with their *śānti* rituals to the Babylonian omens with their *namburbi* rituals, though no exact parallels exist since the Indian omens are without apodoses. It is possible, however, though not demonstrable, that the original of these three Sanskrit texts was at least in part dependent on a Mesopotamian prototype that reached India slightly before or after the Achaemenid occupation of Gandhāra in the sixth century B.C.[7]

Much clearer is the transmission of Mesopotamian omen texts—both protases and apodoses—to India in the fifth and fourth centuries B.C., for the contemporary Sanskrit and Prakrit literature is replete with references to and

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[1] A. Weber, "Zwei vedische Texte über Omina und Portenta," AAWB, Phil.-hist. Kl. (1858), 313–413.

[2] Edited by M. Bloomfield, "The Kāuçika-sūtra of the Atharva-veda," JAOS 14 (1890), i–lxviii and 1–416.

[3] N. Tsuji, "On the Formation of the Adbhuta-Brāhmaṇa," ABORI 48–49 (1968), 173–178; at the end of this article Tsuji gives a list of passages on omens in the Gṛhyasūtras and Smṛtisūtras.

[4] Edited with the Vedārthaprakāśa of Sāyaṇa by B. Ramachandra Sharma, KSVS 9, Tirupati 1967; English translation by W. B. Bollée, Thesis Utrecht 1956.

[5] Edited as ASS 105, Poona 1937.

[6] Pariśiṣṭa LXVII in G. M. Bolling and J. von Negelein, The Pariśiṣṭas of the Atharvaveda, 2 vols., Leipzig 1909–1910; see also D. J. Kohlbrugge, Atharvaveda-Pariśiṣṭa über Omina, Thesis Utrecht 1938.

[7] D. Pingree, "Mesopotamian Astronomy and Astral Omens in Other Civilizations," Rencontre Assyriologique.

examples of such omens.[8] They are related mainly to two cuneiform series: Šumma ālu,[9] which deals with terrestrial omens affecting individuals, and Enūma Anu Enlil,[10] which deals with atmospheric and celestial omens affecting countries or their rulers. The Buddha was represented in the Dīghanikāya (I 1, 24) as condemning the Brāhmaṇas who earn their living from the useless knowledge of omens, but, in a later Buddhist story, the Śārdūlakarṇāvadāna,[11] written probably in the first century A.D., the display by an outcaste of a knowledge of astral omens similar to those of Enūma Anu Enlil and of the mathematical astronomy adapted from Babylonia by Lagadha is used to establish the outcaste's equality with a Brāhmaṇa. The earliest version of this *avadāna* includes sections on the characteristics of the native born when the Moon is in each *nakṣatra* (61—62); the character and/or fate of an individual or people if a city is entered when the Moon is in each *nakṣatra* (pp. 62—67; in verse); a list of the countries and regions of India dominated by each *nakṣatra* (pp. 67—68); the affect on the country if the first rainfall in the last month of *grīṣma* (summer) occurs as the Moon is in each *nakṣatra* (pp. 68—79); what a lunar eclipse in each *nakṣatra* portends (pp. 79—81); actions to be accomplished when the Moon is in each *nakṣatra* (pp. 81—98; in verse); a similar description of actions to be undertaken when the Moon is in one of seven categories of *nakṣatras*[12] (pp. 98—99; mixed prose and verse); prognostications from the *nakṣatra* occupied by the Moon on the occasion of an earthquake and from other phenomena associated with earthquakes (pp. 108—123; in verse); the course of a disease that begins when the Moon is in each *nakṣatra* (pp. 123—128; in verse); in how long a period of time a prisoner will be released if he is bound when the Moon is in each *nakṣatra* (pp. 128—129); and the fate of a woman depending on the part of her body that bears a *tilaka* (pp. 129—132; in verse). All of this material was translated into Chinese by Chu Lüh-yen and Che K'ien in the Kingdom of Wu in about 250, and most of it by Dharmarakṣa at Lo-yan in about 300.[13] Before the Śārdūlakarṇāvadāna had been translated into Tibetan by Ajitaśrībhadra and Śākyaprabha in about 864 there had been

[8] Many references to omens and their *śāntis* in the literature of this and later periods are collected by P. V. Kane, History of Dharmaśāstra, vol. 5, pt. 2, Poona 1962, pp. 719—814.

[9] The most recent treatment is the thesis by S. M. Moren, The Omen Series Šumma Alu: A Preliminary Investigation, University of Pennsylvania 1978.

[10] E. F. Weidner, "Die astrologische Serie Enûma Anu Enlil," AfO 14 (1941/44), 172—195 and 308—318; 17 (1954/56), 71—89; and 22 (1968/69), 65—75. See alsc the new edition of the stellar omens being prepared by E. Reiner and D. Pingree, Babylonian Planetary Omens, of which two fascicles have appeared (Malibu 1975 and 1981).

[11] Edited by S. Mukhopadhyaya, Santiniketan 1954.

[12] As it stands the text discusses only the categories *dhruva* (fixed), *kṣipra* (swift), and *dāruṇa* (sharp); the rest can be supplied from such texts as the Parāśaratantra (see D. Pingree in Viator 7 (1976), 175).

[13] The translation into Chinese made by Ān Shi-kāo in about 150 contains only a brief summary of the story without the elaborate astronomical and omen sections.

added to it a second chapter on the native born as the Moon is in each *nakṣatra (nakṣatrajanmaguṇa)* (pp. 132–135; in verse). At an even later date the Sanskrit text was expanded by the addition of a number of chapters on omens, most of which are in verse. Their subjects include *utpātas*—primarily celestial or atmospheric phenomena affecting or associated with the Sun or the Moon in specific *nakṣatras* and/or months or *pakṣas* (pp. 136–147); birth-marks *(pinya?)* resulting from the *nakṣatra* occupied by the Moon at the time of the native's birth (pp. 147–151); boils or pimples *(piṭaka)* as omens (pp. 151–154); two chapters on oneiromancy (pp. 154–164); astral and atmospheric omens in each month (pp. 164–166; in prose); omens from the wagtail *(khañjarīṭaka)* (pp. 166–167); from the howling of the jackal *(śivāruta)* (pp. 167–171; in prose); palmistry *(pāṇilekhā)* (pp. 172–175); omens from the cawing of crows *(vāyasaruta)* (pp. 175–180); omens from the shape and appearance of a house *(dvāralakṣaṇa)* (pp. 180–182); determining the thought of the client from his touching by chance one of twelve circles drawn by the astrologer (pp. 183–187); the qualities of a maiden having various physical features *(kanyālakṣaṇa)* (pp. 187–191); garments as the Moon is in each *nakṣatra* (p. 192); the omens used for agriculture (pp. 193–197); supernatural beings (pp. 197–200; very corrupt); omens from smoke *(dhūmika)* (p. 201); and actions to be undertaken on each *tithi* of a *pakṣa (tithikarma)* (pp. 201–203). Thus, to the original contents of the omen sections of the text, which depend almost exclusively on the *nakṣatra* occupied by the Moon, have been appended the most heterogeneous material relating to dreams, physiognomy, the cries of animals and birds, and so on. All of these forms of omens, of course, occur in other texts.

The earliest extant such text is the first version of the Gargasaṃhitā,[14] a work probably written in the first century B.C. or A.D. and taking the form of a dialogue between Krauṣṭuki (Ṛṣiputra) and Garga. This vast, unpublished text originally contained some sixty-two *aṅgas*. The first three utilize the Moon and the *nakṣatras*, and are related to the omens of the original Śārdūlakarṇāvadāna; *karmaguṇa* (on actions undertaken at specified times), *candramāna*, and *nakṣatrakendrabha*. The next nine (*aṅgas* 4–12) deal with the motion of celestial bodies—the Moon's node (Rāhu), Jupiter, Venus, comets (Ketu), Saturn, Mars, Mercury, the Sun, and Canopus (Agastya). There follow four (*aṅgas* 13–16) on the circles *(cakra)* of intermediate directions *(antara)*, deer *(mṛga)*, dogs *(śvā)*, and winds *(vāta)*. Then come three (*aṅgas* 17–19) sciences *(vidyā)*—of houses *(vāstu)*, of limbs *(aṅga)*, and of crows *(vāyasa)*—and three (*aṅgas* 20–22) conjunctions of the Moon with the *nakṣatras* Svāti, Āṣāḍha, and Rohiṇī. *Aṅga* 23 lists the countries dominated by each *nakṣatra*, and *aṅga* 24 gives prognostications involving rainfall. The following seven (*aṅgas* 25–31) are devoted to the planets—the things they influence *(kośa)*, their conjunctions

[14] CESS A 2, 116a–117b; A 3, 29b; and A 4. I am also deeply indebted to John Mitchiner for his full account of the contents of the Gargasaṃhitā and of some of its imitators.

(samāgama), their *amrādakṣiṇya* (is this *abhrādarśana*, "obscuration by clouds"?), their conflicts *(yuddha)*, their configurations beginning with the "triangle" *yoga (śṛṅgāṭaka)*, their "traditions" *(purāṇa)*, and the ripening *(pāka)* of their effects. Then come three (*aṅgas* 32–34) on military omens; they are expeditions *(yātrā)*, fire omens *(agni)*, and the array of the army *(senāvyūha)*. The next two (*aṅgas* 35 and 36) are entitled "variegation of the peacock" *(mayūracitra)* and "lotus of the world" *(bhuvanapuṣkara)*. There follow two (*aṅgas* 37 and 38) on rituals: the offering of oblations *(balyupahāra)* and the performance of *śānti* rites. *Aṅga* 39 is a collection of various omens *(utpāta)* portending disaster to countries; and *aṅga* 40 is entitled "the treasure on the scales" *(tulākośa)*. *Aṅga* 41 is the well known historical prophecy, the Yugapurāṇa.[15] In *aṅga* 42 are collected omens based on the cries *(ruta)* of various birds and animals: crows *(vāyasa)*, woodpeckers *(śatapattra)*, bluejays *(cāṣa)*, cranes *(sārasa)*, *pesamas* or *pesamās* (?), cows *(śakkarikā)*, peacocks *(mayūra)*, *visphoṭīs* (?), *ciriṇī*-crows, skylarks *(bhāradvāja)*, doves *(kapotī)*, cuckoos *(kokila)*, vultures *(śakuni)*, owls *(ulūka)*, *piṅgalā*-owls, peahens *(nartakā)*, *sundarikās* (?), partridges *(tittiri)*, cats *(biḍāla)*, hares *(śaśaka)*, asses *(gardabha)*, vixens *(lomaśā)*, bulls *(vṛṣabha)*, *lopā*-birds, and spotted antelopes *(pṛṣata)*. There follows a section (*aṅga* 43) on tears in garments. The next (*aṅga* 44) is entitled "the tradition *(purāṇa)* of Bṛhaspati (or of Jupiter)." *Aṅga* 45 presents omens involving "Indra's banner" *(indradhvaja)*. The next five (*aṅgas* 46–50) employ as omens the characteristics of several kinds of animals—rams, tortoises, women, elephants, and cows. *Aṅga* 51 is entitled "the appearance *(saṃsthāna)* of Venus." There follows a section (*aṅga* 52) on the "pregnancy" *(garbha)* of the clouds before the beginning of the rainy season, and then comes one (*aṅga* 53) on water divining *(dakārgala)*. The next group of five chapters (*aṅgas* 54–58) deals with "atmospheric" phenomena: violent storms *(nirghāta)*, earthquakes *(bhūmikampa)*, halos *(pariveṣa)* around the Sun and the Moon, meteors *(ulkā)*, and halos again. *Aṅga* 59 is on the nature of the seasons *(ṛtusvabhāva)*, but the next (*aṅga* 60) is devoted to omens occurring at dawn or evening *(sandhyā)*. *Aṅga* 61 is a second chapter on meteors. And finally, *aṅga* 62 describes the *nakṣatra* melothesia of the celestial *puruṣa*. A *mayūracitraka* on various *utpātas* is appended to the text.

This vast panoply of omens, a very large number of which can be paralleled in cuneiform texts, has been extraordinarily influential on Indian life and

[15] See K. P. Jayaswal, "Historical Data in the Garga-Saṃhitā and the Brahmin Empire," JBORS 14 (1928), 397–421, and "The Paris Manuscript of the Garga Saṃhitā," JBORS 15 (1929), 129–133; K. H. Dhruva, "Historical Contents of the Yugapurāṇa," JBORS 16 (1930), 18–66; D. R. Mankad, "A Critically Edited Text of the Yuga-Purāṇa," JUPHS 20 (1947), 32–64, reprinted Vallabhvidyanagar 1951; A. K. Narain, The Indo-Greeks, Oxford 1957, pp. 174–179; and D. C. Sircar, "The Account of the Yavanas in the Yuga-Purāṇa," JRAS (1963), 7–20; "The Yavanas and Mathurā," JAIH 6 (1972–73), 168–173; and "Problems of the Yugapurāṇa," in his Studies in the Yugapurāṇa and Other Texts, Delhi 1974, pp. 1–16. A new edition by J. Mitchiner should appear shortly.

literature. Parts have been used by the authors of the Mahābhārata and of some of the *purāṇas;* and omens in general have become as important an aspect of life in India as they were in Mesopotamia. The technical texts on divination (usually entitled *saṃhitā*) are to a large extent dependent on the Gargasaṃhitā; of these the most important is the Bṛhatsaṃhitā of Varāhamihira, which will be described below. It was also used with other texts by the composer of several of the Pariśiṣṭas of the Atharvaveda; these are: L on lunar omens (*candraprātipadika;* cf. GS 2–3), LI on planetary conflicts (*grahayuddha;* cf. GS 28), LII on planetary conjunctions (*grahasaṅgraha;* cf. GS 26), LIII on the motion of the Moon's node (*rāhucāra;* cf. GS 4), LIV on the motion of comets (*ketucāra;* ascribed to Bhārgava, but cf. GS 7), LV on seasonal comets *(ṛtuketulakṣaṇa)*, LVI on the distribution of the countries on the back of the "tortoise" earth among the *nakṣatras* (*kūrmavibhāga;* cf. GS 23), LVII on the "circles" among the *nakṣatras* of Agni, Vāyu, Varuṇa, and Mahendra *(maṇḍalāni)*, LVIII on the "burning of the directions" *(digdāha)*, LVIIIb on meteors and falling stars (*ulkā;* cf. GS 57 and 61), LIX on lightning *(vidyut)*, LX on violent storms (*nirghāta;* cf. GS 54), LXI on omens occurring at dawn or evening (⟨*sandhyā*⟩; cf. GS 60), LXII on earthquakes (*bhūmikampa;* cf. GS 55), LXIII on halos (⟨*pariveṣa*⟩; cf. GS 56 and 58), LXIV on *utpātas* (cf. GS 39), LXV on sudden rainstorms *(sadyovṛṣṭi)*, and LXVIII on oneiromancy *(svapna)*.

There are several other works entitled Gargasaṃhitā, [1] at of these only one—the second GS[16]—deals with omens. It belongs to a class of *saṃhitās* attributed to *ṛṣis* that lie intermediate between omen texts and texts on *muhūrtaśāstra*. They will be described in a later section.

Several of the works associated with Garga contain sections on meteorological predictions, and particularly on the prediction of the rains. A separate work on that subject attributed to Garga, the Meghamālā,[17] has also been preserved. The phenomena utilized include winds, clouds, mock Suns *(pratisūrya)*, halos, violent storms, and eclipses. Another Meghamālā is ascribed to Śiva. To Garga is also attributed a work on a form of divination also known in Mesopotamia, that from falling lizards. It bears several titles, all variations on Pallīsaraṭapatanavidhāna.[18] Similar texts are ascribed to other *ṛṣis* such as Śaunaka.

In the early fourth century Garga was named as an authority on omens along with Parāśara[19] by Mīnarāja in his Vṛddhayavanajātaka (67, 5). This Parāśara is undoubtedly the one cited by Varāhamihira concerning the motion of Mercury (BS 7, 8); as an authority on comets along with Garga, Asita,[20] and

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[16] CESS A 2, 117b—118a.
[17] CESS A 2, 120a.
[18] CESS A 2, 120b; A 3, 30a; and A 4.
[19] CESS A 4.
[20] CESS A 1, 47b.

Devala[21] (BS 11, 1); concerning planetary conflicts (BS 17, 3); as an authority, together with Garga, Kāśyapa,[22] and Vajra, on the "pregnancy" of clouds (BS 21, 2); as agreeing with Garga and Vasiṣṭha on the extent of the area on which a predicted rain will fall (BS 23, 4); as one of the experts, along with Bṛhaspati,[23] Garga, Kāśyapa, and Maya[24] on the Moon's conjunction with Rohiṇī (BS 24, 2); and as addressing his discussion of the characteristics of cows to Bṛhadratha (BS 60, 1). The work of Parāśara on omens is probably the lost prose and verse Parāśaratantra cited frequently by Bhaṭṭotpala in his commentary on the BS. The omen section of Mīnarāja's VYJ comprises *adhyāyas* 64–71, which are respectively on signs of death, on counter-omens to evil portents, on oneiromancy, on various omens, on the cawing of crows, on the cuckoo laying eggs *(śyāmāceṣṭita)*, on the activities of dogs *(śvāceṣṭita)*, and on the activities of cows *(goceṣṭita)*. Other early authorities on omens mentioned by Varāhamihira, and therefore antedating the middle of the sixth century, include[25] Atri[26] on *utpātas*, which was used by Garga (BS 45, 1); Ṛṣabha,[27] who summarized the views of Śakra (Indra[28]), Śukra (Bhṛgu), Vāgīśa (Bṛhaspati), Kapiṣṭhala,[29] Garutmān,[30] Bhāguri,[31] and Devala on *śakuna* (BS 85, 1); the Mahārājādhirāja of Avanti, Dravyavardhana,[32] who was an authority on *śakuna* (he was probably an Aulikara monarch ruling in about 500) (BS 85, 2); Nārada on comets (BS 11, 5) and as Bṛhaspati's student regarding the Moon's conjunction with Rohiṇī (BS 24, 2) (this Nārada is different from the author of the currently available Nāradasaṃhitā, but Varāhamihira may have in mind Nārada's Mayūracitraka); Bādarāyaṇa[33] on the ripening of grain (BS 39, 1); Bhṛgu[34] on *śakuna* (BS 85, 43); Manu[35] on water divining (BS 53, 99); and Sārasvata, also on water-divining (BS 53, 99).

The Bṛhatsaṃhitā[36] itself is the classical work on *saṃhitā*. It is divided in

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[21] CESS A 4.

[22] CESS A 2, 30b, and A 4. I regret that no copy of his Kāśyapasaṃhitā is available to me.

[23] CESS A 4.

[24] CESS A 4.

[25] P. V. KANE, "Varāhamihira and Utpala: their Works and Predecessors," JBBRAS, NS 24–25 (1948–49), 1–31.

[26] CESS A 1, 39b–40a.

[27] CESS A 1, 59a.

[28] CESS A 1, 55a.

[29] CESS A 2, 19b.

[30] CESS A 2, 115b.

[31] CESS A 4.

[32] CESS A 3, 123b.

[33] CESS A 4.

[34] CESS A 4.

[35] CESS A 4.

[36] Edited by H. KERN as BI 48, Calcutta 1865; published with a Marāṭhī translation, Ratnāgiri 1873; edited with his own Hindī *ṭīkā* by B. PRABHU, Benares 1880; edited by JĪVĀNANDA VIDYĀSĀGARA, Calcutta 1880; edited by PAÑCĀNANA TARKARATNA, Calcutta 1882; edited with his own Hindī translation by DURGĀ-

different editions into 106 or 107 *adhyāyas*,[37] which cover most of the topics of the GS.[38] The remaining topics include: the moral, physical, and intellectual attributes of an astrologer (BS 2; cf. YJ 51, 12–20); the motion of Ursa Maior (Saptarṣis) (BS 13); the characteristics of the years belonging to each of the planets (BS 19; see YJ 78, 11–17); on sudden rainstorms (BS 28); on flowers and creepers (BS 29); on the "burning of the directions" (BS 31; see Pariśiṣṭa LVIII); on rainbows (*indrāyudha;* BS 35); on the Gandharva cities formed by clouds (BS 36); on mock Suns (BS 37); on the ripening of grain (BS 39); on the objects associated with each zodiacal sign (BS 40; see YJ 4); on the fluctuation of prices (*arghakāṇḍa;* BS 41); on the lustration of arms (*nīrājana;* BS 43); on wagtails (BS 44; see Śārdūlakarṇāvadāna, pp. 166–167); on the Puṣya ablution (BS 47); on honorary turbans (*paṭṭa;* BS 48); on swords (*khaḍga;* BS 49); on boils or pimples (BS 51; see Śārdūlakarṇāvadāna, pp. 151–154); on arbori-

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PRASĀDA, Lucknow 1884; published with a Bengālī translation in Aruṇodaya 1 (1890), no. 4; edited with Utpala's *vivṛti* by SUDHĀKARA DVIVEDIN as VSS 10, 2 vols., Benares 1895–1897, reprinted by A. TRIPĀṬHĪ as SBG 97, 2 vols., Vārāṇasī 1968; edited with his own Hindī translation by BALADEVAPRASĀDA MIŚRA, Bombay 1897, reprinted Bombay 1918, Bombay 1952, and Bombay 1955; edited with the Bengālī translation of DHĪRĀNANDA KĀVYANIDHI by PAÑCĀNANA TARKARATNA, 2nd ed., Calcutta 1910; edited with an English translation by V. SUBRAHMANYA SASTRI and M. R. BHAT, 2 vols., Bangalore 1947; and edited with his own Hindī *ṭīkā* by ACYUTĀNANDA JHĀ as VSG 41, Vārāṇasī 1959. The beginning of an edition with a Kannaḍa translation appeared in Ātmānanda (1910), pts. 1–4. Adhyāya 53, on water divination, was edited with a Marāṭhī translation by V. N. GORE, Bombay 1911. There are English translations by H. KERN, "The Bṛhat-Saṁhitā; or, Complete System of Natural Astrology of Varāhamihira. Translated from Sanskrit into English," JRAS (1870), 430–479; (1871), 45–90 and 231–288; (1873), 36–91 and 279–338; and (1875), 81–134, reprinted in his Verspreide Geschriften, 16 vols., 's-Gravenhage 1913–1929, vol. 1, pp. 169–319, and vol. 2, pp. 1–154; and by N. CHIDAMBARAM IYER, 3 vols., Madura 1884–1885.

[37] Utpala's version, to which I here refer, omits the other editions' *adhyāya* 38 (*rajolakṣaṇa;* on haze); it is also omitted from Varāhamihira's own list of *adhyāyas* (BS 106, 5).

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BS	GS	BS	GS	BS	GS	BS	GS
3	11	16	25	33	57, 61	69	48
4	2	17	28	34	56, 58	70	43
5	4	18	26	38	54	86	13
6	9	20	29	42	45	87	42
7	10	21–22	52	45	39	88	15
8	5	23	24	46	35	94	19
9	6	24	22	50	18	96	31(?)
10	8	25	20	52	17	97–99	1
11	7	26	21	53	53	104	62
12	12	27	16	60	50		
14	23	30	60	63	47		
15	3(?)	32	55	66	49		

culture (*vṛkṣāyurveda;* BS 54); on temples (*prasāda;* BS 55); on adamantine glue (*vajralepa;* BS 56); on images (*pratimā;* BS 57); on entering the forest to find the appropriate trees for making images (BS 58); on installing the images (BS 59); on dogs (BS 61; see VYJ 70); on cocks (*kukkuṭa;* BS 62); on goats (*chāga;* BS 64); on horses (*aśva;* BS 65); on men (*puruṣa;* BS 67); on the five *mahāpuruṣas* (BS 68); on fly-whisks (*cāmara;* BS 71); on umbrellas (*chatra;* BS 72); in praise of women (*strīpraśaṃsā;* BS 73); on causing affection (*saubhāgyakaraṇa;* BS 74); on aphrodisiacs (*kāndarpika;* BS 75); on perfumes (*gandhayukti;* BS 76); on the union of women and men (BS 77); on beds and seats (*śayyāsana;* BS 78); the examination of jewels[39] (*ratnaparīkṣā;* BS 79); on pearls (*muktā;* BS 80); on rubies (*padmarāga;* BS 81); on emeralds (*marakaṭa;* BS 82); on lamps (*dīpa;* BS 83); on sticks for cleaning the teeth (*dantakāṣṭha;* BS 84); animal and bird omens (*śākuna;* BS 85); on the howling of the jackal (BS 89; see Śārdūlakarṇāvadāna, pp. 167–171); on the activities of animals (*mṛgaceṣṭita;* BS 90); on the movements of cows (BS 91; see VYJ 71); on the movements of horses (*aśveṅgita;* BS 92); on the activities of elephants (BS 93); further animal and bird omens (BS 95); on natives born when the Moon is in each *nakṣatra* (BS 100; see Śārdūlakarṇāvadāna, pp. 61–62 and 132–135); the correspondence of zodiacal signs to *nakṣatras* (BS 101); on the horoscope of the wedding[40] (*vivāhapaṭala;* BS 102); on the planets' transits of the astrological places in the base-nativities (*grahagocara*, a topic appropriate to genethlialogy rather than divination; BS 103; see YJ 43). The wealth of information on the material, social, and religious life of India both in Varāhamihira's own time and in earlier periods (the latter can be assessed only by comparing the BS with the GS and their Babylonian sources) contained in the BS is obviously enormous.[41]

The popularity of the BS was great, though the vastness of the text precluded much commentarial work. The chief effort in that direction that we possess is the extremely valuable *vivṛti* completed by Bhaṭṭotpala in Kāśmīra in 967; based on Bhaṭṭotpala's work is the Utpalaparimala composed by Bhāskarārya Yogin[42] at Śrīraṅga on the Kāverī in 1235. The BS with Bhaṭṭotpala's *vivṛti* was read by al-Bīrūnī in the Panjāb in preparation for writing his India in 1030/1031. It was translated into Persian by 'Abd al-'Azīz Dihlawī[43] for Fīrūz Shāh Tughlūq in about 1375; *adhyāyas* 66 and 68 were translated into Tamil anonymously;[44]

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[39] Adhyāyas 79–82 are edited with a French translation by L. Finot, Les lapidaires indiens, Paris 1896, pp. 59–75.

[40] Utpala claims that this *adhyāya* is based on the work of an otherwise unknown Vindhyavāsin. See below for Varāhamihira's independent treatise entitled Vivāhapaṭala.

[41] Not entirely satisfactory is A. M. Shastri, India as Seen in the Bṛhatsaṃhitā of Varāhamihira, Delhi–Patna–Varanasi 1969.

[42] CESS A 4.

[43] CESS A 2, 13a–13b.

[44] Edited by T. N. Subramaniam, Sāmudrikā lakṣaṇa, Madras GOS 126, Madras 1959, pp. 109–126.

and there seems to exist a paraphrase in Siṃhalese.[45] Varāhamihira himself wrote an abridgement, the Samāsasaṃhitā,[46] of which only quotations, notably in Bhaṭṭotpala's *vivṛti* on the BS, now survive.

Probably not far in time from Varāhamihira an unnamed Jaina composed an immense work in Prakrit on omens entitled Aṅgavijjā,[47] which classifies every perceptible object in the world as a ominous entity. It remains an inadequately explored treasure of the material aspects of Indian culture. Another Jaina, claiming to be Bhadrabāhu,[48] the last *śrutakevalin*, composed on mainly celestial omens a Bhadrabāhusaṃhitā or Nimitta[49] in the period between the BS, on which much of the work is based,[50] and Bhaṭṭotpala, who cites BBS 15, 92–95, on BS 9, 37. The subjects not directly corresponding to Varāhamihira's that Bhadrabāhu takes up are lightning (BBS 5; cf. Pariśiṣṭa LIX); clouds (BBS 6 and 8; cf. second GS 14); military expeditions (BSS 13; cf. GS 32); planetary omens (BBS 25); and oneiromancy (BBS 26; cf. VYJ 66). A third Jaina text (though some manuscripts make it Śaiva) written in this period is by Garga,[51] who is usually identified with the *guru* named by Siddharṣi in 905; this is variously titled Pāśakevalī,[52] Marutajñānapraśna, etc. It is an elaborate treatise on divination by means of dice, giving the interpretation of each of the combinations of three of the numbers 1, 2, 3, and 4, in all possible orders.

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[45] H. M. Gunasekera, Catalogue of Páli, Siṃhalese, and Sanskrit Manuscripts in the Colombo Museum Library, Colombo 1901, p. 34.

[46] A. M. Shastri, "Contribution towards the Reconstruction of the Samāsa-Saṃhitā of Varāhamihira," Bhāratīya Vidyā 23 (1963), 22–39.

[47] Edited by Muni Puṇyavijaya as PTSS 1, Banaras 1957.

[48] CESS A4.

[49] Edited by A. S. Gopāṇī as SJS 26, Bombay 1949, and with a Hindī translation by N. Shastry as JMJSG 25, Kāśī 1959. The additional material in the latter edition is not justified by BBS 1, 15–17.

[50] Gopāṇī, *prastāvanā* pp. 6–19, has demonstrated the following relationships between the BBS and the BS.

BBS	BS	BBS	BS
2–3 (meteors)	33	16 (Saturn's motions)	10
4 (halos)	34	17 (Jupiter's motions)	8
7 (dawn and twilight omens)	30	18 (Mercury's motions)	7
9 (winds)	27	19 (Mars' motions)	6
10 (rains)	23	20 (Rāhu's motions)	5
11 (Gandharva cities)	36	21 (comets)	11
12 (pregnancy of clouds)	22	22 (Sun's motions)	3
14 *(utpātas)*	45, 46	23 (Moon's motions)	4
15 (Venus' motions)	9	24 (planetary conflicts)	17

[51] CESS A2, 122b–126a; A3, 30b–31a; and A4.

[52] Edited by A. Weber, "Über ein indisches Würfel-Orakel," MPAWB (1859), 158–180; see also his Indische Streifen, vol. 1, Berlin 1868, pp. 274–307; published at Kāśī in 1884; published with a Telugu translation, Madras 1890; edited by A. F. R. Hoernle, The Bower Manuscript, Calcutta 1893, pp. 203–221; and edited by J. E. Schröter, Borna 1900.

Though Bhaṭṭotpala quotes from both Nārada (on BS 11, 5) and Vasiṣṭha (on BS 5, 3; 32, 2; and 57, 8) in his *vivṛti* on the BS, none of these citations occurs in the currently available Nāradasaṃhitā and Vasiṣṭhasaṃhitā; the relation of his citations of verses of Bṛhaspati (on BS 35, 3; 52, 2–3; and 52, 87–88) to the extant Bṛhaspatisaṃhitā[53] cannot as yet be determined. Other authorities on omens whom Bhaṭṭotpala was able to quote in 967 include Nandin,[54] Bhānubhaṭṭa,[55] and Śālihotra, as well as the authority, Samudra, after whom the science of physiognomy was later named *sāmudrika* (on BS 67 and 69).

Al-Bīrūnī, in his India (14), lists the names of seven authors of *saṃhitās:* Māṇḍavya,[56] Parāśara, Garga, Brahman,[57] Balabhadra, Divyatattva,[58] and Varāhamihira. Of these authors, Balabhadra and Divyatattva are not known from Sanskrit sources to have composed *saṃhitās,* though there is an Adbhutataraṅgiṇī on omens by a Balabhadra.[59]

Vasantarāja composed his Śakunārṇava[60] at or near Vārāṇasī in the 1090's since he dedicated it to the Gāhaḍavāla Candradeva (ca. 1089—ca. 1103). In a verse toward the beginning (1, 27) he names as his predecessors Atri, Garga, Guru (Bṛhaspati), Śukra (Bhṛgu), Vasiṣṭha, Vyāsa, Kautsa (perhaps Aṅgiras[61]), Bhṛgu, and Gautama.[62] Its twenty *vargas* give omens from the cries and movements of birds and animals. A *ṭīkā* was written by Bhānucandra Gaṇi[63] of the Tapāgaccha in about 1559 in the empire of Akbar (1556—1605); it was edited by Bhānucandra's pupil, Siddhicandra.

In about 1160 Durlabharāja,[64] a scion of the Prāgvāṭa family of Gujarāt who was made a *mahattara* by the Caulukya Kumārapāla (ca. 1143—1152), began a Sāmudrikatilaka[65] that was finished by his son, Jagaddeva.[66] This is the earliest complete Sanskrit text on physiognomy and palmistry that we possess, though we have seen that the subject was earlier treated in the Śārdūlakarṇāvadāna (pp. 129—132, 147—154, 172—175, and 187—191), the GS (18 and 48), the BS (50, 51, 67, and 69), and other texts. Durlabharāja adds

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[53] CESS A 4.
[54] CESS A 3, 131b.
[55] CESS A 4.
[56] CESS A 4.
[57] CESS A 4.
[58] CESS A 3, 112a.
[59] CESS A 4.
[60] Edited with the *ṭīkā* of Bhānucandra by Śrīdhara Jaṭāśaṅkara, Bombay 1883; see also E. Hultzsch, Prolegomena zu des Vasantarāja Śākuna nebst Textproben, Leipzig 1879.
[61] CESS A 1, 35a.
[62] CESS A 2, 145b.
[63] CESS A 4.
[64] CESS A 3, 116b—117a, and A 4.
[65] Edited with a Hindī translation by Rādhākṛṣṇa Miśra, Bombay 1956.
[66] CESS A 3, 54b—55a, and A 4.

(in 1, 9) to the authors whose names we have already encountered Lakṣaka and Sumanta, of whom nothing further is known, and the famous Paramāra Bhojarāja of Dhārā, whose work on *sāmudrika* has not survived.

Durlabharāja's son, Jagaddeva, besides completing his father's Sāmudrikatilaka, wrote an important treatise on oneiromancy, the Svapnacintāmaṇi,[67] in about 1175. Again, though this is the earliest independent treatise on *svapna* that we possess, the interpretation of dreams goes back in Sanskrit literature to the Ṛgveda,[68] and had been treated systematically since at least the time of Mīnarāja (VYJ 66).[69] Aside from some oneiromancies preserved in various *purāṇas*—e.g., Matsyapurāṇa 241 and Brahmavaivartapurāṇa, Kṛṣṇajanmakhaṇḍa 77 and 82—the most common Sanskrit text on the interpretation of dreams is the Svapnādhyāya attributed to Bṛhaspati.[70]

Contemporary with Durlabharāja and Jagaddeva was Narapati,[71] who completed his Narapatijayacaryā or Svarodaya[72] at Aṇahilanagara in Saurāṣṭra in 1177. This work describes various arrangements *(cakras)* of letters associated with time divisions and astrological entities, magical pictures of animals and objects (also called *cakras*), and arrangements of *nakṣatras*, months, and numbers relative to the directions *(bhūmis)*, all of which promote the military victory of their user. Narapati names as his sources (1, 4—10) seven *yāmalas* (of Brahma, Viṣṇu, Rudra, Ādi, Skanda, Kūrma, and Devī), the Yuddhajayārṇava, the Svarabhairava, the Raṇāhvayatantra, the Jayapaddhati, and various other tantric texts. The NJ was commented on by Narahari[73] during the reign of Bhairavendra, who ruled Mithilā from ca. 1480 till ca. 1515 (Vyākhyāplava), and by Harivaṃśa Pāṭhaka in ca. 1500 (Jayalakṣmī); the latter was revised by Harivaṃśa's son, Mahādeva,[74] in 1520. Based on the NJ is the Balatantrama-

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[67] Published with a Marāṭhī translation, Bombay 1848; edited with a Marāṭhī *ṭīkā* by J. H. Āṭhalye, Ratnāgiri 1873; edited with a Telugu version by Śeṣācala Śāstri, Madras 1911; and edited with a German translation by J. von Negelein, Giessen 1912.

[68] See, for example, the references given by Tsuji in ABORI 48—49 (1968), 177 fn. 5, and in von Negelein's edition of Jagaddeva, p. 378.

[69] Predictions of the substance of dreams on the basis of the zodiacal signs and planets are given by Sphujidhvaja (YJ 69—70). For other early oneiromancies see Śārdūlakarṇāvadāna, pp. 154—164; Pariśiṣṭa LXVIII; and BBS 26. See also R. G. Harshe, "Two Illustrated Manuscripts on Dreams," Bhāratīya Vidyā 9 (1948), 246—268.

[70] CESS A 4.

[71] CESS A 3, 137a—142a, and A 4.

[72] Published with the Jayalakṣmī of Harivaṃśa, Benares 1882; at Lucknow in 1896; at Meraṭha in [1900]; at Meerut in 1902; with the Jayalakṣmī of Harivaṃśa, Bombay 1906, reprinted Bombay 1934 and Bombay 1955; at Meerut in 1920; and edited with his own *ṭīkā* by G. Pāṭhaka as KSS 205, Vārāṇasī 1971. The Ahibalacakra section was edited with a Hindī *ṭīkā* by V. Dvivedin as VSG 19, Banārasa 1955.

[73] CESS A 3, 143a—143b, and A 4.

[74] CESS A 4.

hārṇava of Ādityadeva,[75] on which a *ṭīkā* in Telugu was written by Daivajñadāsa,[76] and the Sāroddhāra composed by Śraddhā Ṛṣi in about 1837.

Contemporaneously with the three authors from Saurāṣṭra the Mahārājādhirāja of Bengal from ca. 1159 till 1178, Ballālasena,[77] began his Adbhutasāgara[78] in 1168; it was completed by his son and successor, Lakṣmaṇasena, who ruled Bengal from ca. 1178 till 1200. It deals with most of the celestial, atmospheric, and terrestrial omens in a comprehensive fashion, and is the next most popular text in this field after the BS. A similar text, which is probably at least in part dependent on Ballālasena's, is the Adbhutadarpaṇa of Mādhava.[79]

Treatments of omens in the thirteenth century were rare except among the Jainas of Gujarāt and Rājasthān. There are scattered references in the Trailokyaprakāśa written by Hemaprabha Sūri probably in 1248, a work which will be discussed more fully below. And in 1281 Māṇikya Sūri[80] composed a Śakunasāroddhāra. A Hindu, Lāvaṇyaśarman, was the author of a Śakunapradīpa;[81] he himself copied a manuscript of it at Vijāpura in 1344.[82] In some manuscripts of the gigantic Jyotirnibandha composed by Śivarāja between ca. 1475 and 1500 there is inserted a *cārādhyāya;*[83] this is based almost entirely on Varāhamihira's BS (3—13, 17—18, and 20) with a few quotations from the *saṃhitās* of Kāśyapa, Nārada, and Vasiṣṭha.

Slightly before Śivarāja, in about 1450, Rāmacandra wrote at Naimiṣa in Uttarapradeśa a Samarasāra[84] similar in intent and contents to Narapati's NJ. There are commentaries composed by Rāmacandra himself together with his brother, Bharata[85] (Saralā), by Dāmodara[86] (Saṅketamañjarī), and by Dīkṣita Sāṃvatsara.[87] Other works on *svaraśāstra* include the Yuddhajayotsava of Gaṅgārāma[88] and the Pavanavijaya or Svarodaya attributed to Śiva. Other *cakras* are used in interpreting nativities by Prajāpatidāsa,[89] who wrote his Pañcasvarānirṇaya or Granthasaṅgraha[90] before 1625 (the earliest manuscript

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[75] CESS A 1, 48a, and A 3, 15a—15b.
[76] CESS A 3, 123a.
[77] CESS A 4.
[78] Edited by Muralīdhara Śarman, Benares 1905.
[79] CESS A 4.
[80] CESS A 4.
[81] Edited by P. Siṃha as RPG 89, Jodhpur 1968.
[82] LDI 7516 (8990).
[83] Pp. 4—24 of the ASS edition.
[84] Published with his own and Bharata's *ṭīkā*, Benares 1876; edited with the *ṭīkā* of Hanūmat Śarman, Bombay 1911, reprinted Bombay 1952; and edited with the Hindī version of Vāsudeva Gupta by Sītārāma Śarman, Vārāṇasī [ND].
[85] CESS A 4.
[86] CESS A 3, 99a—99b.
[87] CESS A 3, 112b.
[88] CESS A 2, 86a—86b, and A 3, 26b.
[89] CESS A 4.
[90] Edited with the commentaries of Kṛṣṇadatta Jhā and Govindaśarman by R. P. Śukla, 2nd ed., Benares 1941.

was copied in 1631). There are commentaries by Prajāpatidāsa himself as well as by Appaya Dīkṣita[91] and Gauḍa Bhaṭṭācārya.[92] To Mahādeva[93] is ascribed a Pañcapakṣiśakuna[94] employing the five European vowels for divination; the oldest dated manuscript containing this work was copied in 1750. A related text is the Tattvārthacintāmaṇi[95] composed together with a *vṛtti* by Bālakṛṣṇa Vedavṛkṣa[96] at Kāśī in the 1820's.

But a more important author on omens had flourished a century and a half earlier. The Jaina scholar Meghavijaya[97] wrote a Varṣaprabodha[98] similar to the Meghamālās of Garga and Śiva in 1675 and a Hastasañjīvana[99] on palmistry in 1680; in this same year he completed a commentary on the latter work. There are, of course, numerous other anonymous works on omens or works attributed to authors of whom nothing is known extant in Sanskrit and vernacular manuscripts. Nothing further can be said of them in the absence of editions and of critical historical studies.

However, one important method of divination that we cannot fail to mention is geomancy (*ramala*, from the Arabic *raml*), which seems to have been introduced into Sanskrit from Persian sources in the early Mughal period. The principal texts on the subject are the Ramalavaicitrya or Ramalabhāskara[100] of Rāma based on the teachings of the Yavanas (Muslims) (the oldest dated manuscript was copied in 1657); the Ramalenduprakāśa composed by Rudramaṇi Tripāṭhin in 1682; the Ramalarahasya[101] written by Bhayabhañjana Śarman[102] in about 1700; the Ramalotkarṣa or Ramalacintāmaṇi of Cintāmaṇi[103] (the earliest dated manuscript was copied in 1709); the Ramalasāra composed by Śrīpati at Gokula (the oldest dated manuscript was copied in 1718); and the Ramalanavaratna[104] composed by Paramasukha[105] at Kāśī in 1811. Finally,

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[91] CESS A 1, 44a.
[92] CESS A 2, 145a.
[93] CESS A 4.
[94] Published with the *ṭīkā* of Vāmadeva, Calcutta 1842.
[95] I have used University of Pennsylvania 652.
[96] CESS A 4.
[97] CESS A 4.
[98] Published with the Hindī translation of Jvālāprasāda Miśra, Bombay 1903; and edited with his own Hindī *ṭīkā* by Bhagavānadāsa Jaina, Bīkānera 1926. A translation by P. S. Shah was published at Ahmedabad in 1939.
[99] Published as MJG 4, Poona 1925; edited with his own *ṭīkā* and Gujarātī translation by Pratāpa Muni as MJG 8, Indora 1930; and edited with Meghavijaya's own *ṭīkā* on the first two *adhikāras* and a Hindī *ṭīkā* by Gaṇeśadatta Pāṭhaka, Kāśī 1935.
[100] Published Bombay 1915.
[101] Published Bombay 1906.
[102] CESS A 4.
[103] CESS A 3, 47b—49a, and A 4.
[104] Published Kāśī 1869; Bombay 1882; with a Marāṭhī translation, 2nd ed., Beḷagāṃva 1905; with the Hindī *ṭīkā* of Mahīdhara Śarman, Bombay 1918; and with the Hindī *ṭīkā* of Acyutānanda Jhā as HSS 245, Banārasa 1954.
[105] CESS A 4.

the court astrologer of Ranbir Singh, the Mahārāja of Jammu and Kashmir, Viśveśvara (who was still living in 1927), translated a Persian work on scapulomancy into Sanskrit for his royal patron under the title Skandhāsthipraśna.[106]

[106] R. Kak and H. Shastri, A Descriptive Catalogue of Sanskrit Manuscripts, Poona 1927, p. 15.

Chapter V

GENETHLIALOGY

Jātaka

Though already as a part of divination Indians had for long predicted the characteristics of a native on the basis of the *nakṣatra* occupied by the Moon at his birth (e.g., Śārdūlakarṇāvadāna, pp. 61–62), the prediction of the life of the native on the basis of the horoscope cast at his birth—a science that was developed in Hellenistic Egypt in the second century B.C.—was introduced into India only in the second century A.D. In 149/150, probably at the court of the Western Kṣatrapa Rudradāman in Ujjayinī, a Greek manuscript of an astrological text composed in Egypt shortly after 100 A.D. was translated into Sanskrit prose by the head of the Greek community, who was entitled Yavaneśvara. Already in this translation the Hellenistic system had begun to be Hinduized—for instance, the pictures of the Decans and Hours that adorned the Greek manuscript were interpreted by Yavaneśvara in terms of the iconography of Śiva and Pārvatī.[1] Unfortunately, we no longer have Yavaneśvara's translation, but we do possess a very substantial portion of a versification of it made by the ⟨Yavana⟩rāja Sphujidhvaja in 269/270, during the reign of the Western Kṣatrapa Rudrasena II. His Yavanajātaka[2] shows further signs of Hinduization; in particular one suspects that he was responsible for adding the chapter on reincarnation (YJ 43), the lists of minerals, plants, and animals that are influenced by āyurvedic materia medica (YJ 62), and the section on military astrology that is indebted to such sources as the GS (YJ 73–76). The original Greek system was of course further modified so that the predictions fit the social and economic expectations of people born in India, and Indian astrologers after Sphujidhvaja considerably developed genethlialogy by emphasizing some aspects at the expense of others or by creating new and more complex techniques of interpreting horoscopes; but basically all of *jātaka* before the introduction of *tājika* texts in the thirteenth century, and even most of *jātaka* after that, can be traced back to the Yavanajātaka and to the lost work

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[1] D. Pingree, "The Indian Iconography of the Decans and Horās," JWCI 26 (1963), 223–254.

[2] Edited, translated, and commented on by D. Pingree, The Yavanajātaka of Sphujidhvaja, HOS 48, 2 vols., Cambridge, Mass. 1978.

of Satya, who had access to at least one other Sanskrit translation of a Greek text on genethlialogy besides the YJ.

Sphujidhvaja's YJ contains seventy-nine *adhyāyas*, which may be divided into five sections: on nativities (YJ 1–51), on *praśna* or interrogations (YJ 52–72), on *yātrā* or military astrology (YJ 73–76), on *muhūrta* or catarchic astrology (YJ 77–78), and on mathematical astronomy (YJ 79). We have already discussed the last section in the chapter on astronomy; here we shall only review the contents of the first, reserving sections two-four for the relevant chapters of this book.

YJ 1 describes the fundamental elements of genethlialogy—the zodiacal signs *(rāśis)* and their subdivisions (*horās* [ὥρα], *drekāṇas* [δεκανοί], *saptāṃśas*, *navāṃśas*,[3] *dvādaśāṃśas* [δωδεκατημόρια], *triṃśāṃśas* [ὅρια], *sauras*, *cūḍāpadas*, and *liptikas* [λεπτά]); the astrological places *(bhāvas)*, categorized as cardines (*kendras;* κέντρα), succeedent (*pāṇapharas;* ἐπαναφοραί), and cadents (*āpoklimas;* ἀποκλίματα); the planets' exaltations *(uccas);* their triplicities (*trikoṇas;* τρίγωνα); their aspects *(dṛṣṭi);* the various strengths of the zodiacal signs and planets; and the characteristics, spheres of influence, and interrelationships of the planets. The next two *adhyāyas* (YJ 2–3) describe respectively the figures associated with each of the twenty-four *horās* and thirty-six decans. And *adhyāya* 4 lists the objects associated with the zodiacal signs and the planets. The next two chapters deal with conception and gestation (YJ 5), and the circumstances of birth (YJ 6). In *adhyāya* 7 Sphujidhvaja describes the effects on the natives of the planets being in their exaltations or dejections, in their triplicities, in their own, their friends', or their enemies' houses. *Adhyāyas* 8–9 are devoted to the astrological situations that lead to the birth of kings and other leaders. The four *yogas* of the Moon—*sunaphā* (συναφή), *anapharā* (ἀναφορά), *daurudhara* (δορυφορία), and *kemadruma* (κενοδρομία)—are discussed in *adhyāya* 10, the two of the Sun—*veśi* and *vāśi* (φάσις) in *adhyāya* 11. There follow seven chapters (YJ 12–18) on the native born when each of the planets (in the order Sun, Mercury, Venus, Mars, Jupiter, Saturn and Moon) is in each of the zodiacal signs. *Adhyāya* 19 is on the effect of each of the zodiacal signs in the ascendant, *adhyāya* 20 on that of each of the planets. There follows a section on conjunctions of planets: of two and three planets in YJ 21, of four planets (producing religious natives) inYJ 22, of five planets in YJ 23, and of six and seven planets in YJ 24. The next two chapters (YJ 25–26) enumerate the effects of each of the planets' being in each of the places except the ascendent. In *adhyāya* 27 Sphujidhvaja describes three melothesias: of planets, of *horās*, and of decans. There follow four *adhyāyas* (YJ 28–31) on the native born when each *horā*, decan, *saptāṃśa*, and *navāṃśa* is in the ascendent. *Adhyāyas* 32 and 33 are on the Moon's and all the other planets' being in each others' *navāṃśas*, and *adhyāya* 34 on each of the planets in a *dvādaśāṃśa* of each of the zodiacal

[3] On the Indian decans and *navāṃśas* in Sasanian, Arabic, Byzantine, and Latin astrology see D. Pingree, Viator 7 (1976), 146, 151, 172–173, and 181–184.

signs. In YJ 35 Sphujidhvaja very obscurely deals with the theory of the prorogator (ἀφέτης)—a topic ignored by subsequent Indian astrologers until it was reintroduced as the *hillāja* (Arabic *haylāj*) in *tājika* texts. There is then inserted a chapter (YJ 36) on the planetary configurations known as *yogas*. *Adhyāyas* 37—43 are concerned with the computation of the length of the native's life (*āyurdāya;* YJ 37), with fatal configurations (*ariṣṭayoga;* YJ 38), with the periods *(daśās)* and subperiods *(antardaśās)* of the native's life (YJ 39—41), with the cause of his death (YJ 42), and with his next incarnation (YJ 43). There follows a long section (YJ 44—51) on *aṣṭakavarga* or the transits of each of the planets (in the order Sun, Saturn, Jupiter, Venus, Mars, Mercury, and Moon) through the astrological places counted from themselves, from each other, and from the ascendant; this is a fundamental method of continuous horoscopy. Sphujidhvaja's treatment of *jātaka* ends with a description of the ideal astrologer (YJ 51, 13—20).

In large measure based on the YJ, but also dependent on the lost work of Satya,[4] is the Vṛddhayavanajātaka[5] composed by the Yavanādhirāja Mīnarāja[6] in about 300—325 in the realm of the Western Kṣatrapas—that is, during the reign of Rudrasiṃha II (ca. 305—317) or Yaśodāman II (ca. 317—332). This is probably the work called Yavana referred to by al-Bīrūnī (India 14). It is an immense text, twice as long as the YJ, divided into seventy-one *adhyāyas;* the last eight, as we have already noted, are concerned with omens. The rest to a large extent repeat and expand upon the YJ.[7] The remainder deal with the effect of each planet (in the order of the week-days, as henceforth is normal in Sanskrit texts) in each zodiacal sign aspected by each other planet (VYJ 9—15); on the effects of the planets in each astrological place while in various of its *vargas* (VYJ 24—35); on the ascendant aspected by each of the planets (VYJ 36); on the lord of each astrological place in its own and every other place (VYJ 54); and on the "rays" *(raśmi)* of the planets (VYJ 56). Only once—in an astrological *digvijaya* (VYJ 2, 9—10)—does Mīnarāja mention Rāhu as a *graha;* Sphujidhvaja never does. The inclusion of Rāhu and Ketu among the planets to make them nine postdates the VYJ.

[4] The details of the dependence of Indian astrologers on the YJ and on each other will be found in my edition of Sphujidhvaja.

[5] Edited by D. PINGREE as GOS 162—163, Baroda 1976; *adhyāyas* 1—34 with a Hindī *ṭīkā* were published by RĀMASVARŪPA ŚARMAN, New Delhi 1976.

[6] CESS A 4.

[7]

VYJ	YJ	VYJ	YJ
1—2	1	17—24	12—19
3—4	5—6	37—39	10
5—6	37—40	40—51	cf. 21—24
7	cf. 41	40, 52—53	36
8	cf. 44—51	55	19
16	20, 25—26	57	8—9

The following authors of *jātaka* works seem to have written in the fourth or fifth century since they were quoted in the sixth by Varāhamihira: Maya,[8] Yavana, Maṇittha[9] (Μανέθων), and Śaktipūrva (Parāśara)[10] are cited on the maximum length of human life (BJ 7, 1); on the same subject of *āyurdāya* he cites Devasvāmin,[11] Viṣṇugupta (Cāṇakya[12]), and Siddhasena (BJ 7, 7); and Jīvaśarman[13] is mentioned concerning *āyurdāya* (BJ 7, 9) and *rājayogas* (BJ 11, 1). Also earlier than Varāhamihira was a *jātaka* work by Bādarāyaṇa,[14] though it is not clear whether or not the extant Bhāvādhyāya[15] was a part of this, and another by Māṇḍavya.[16]

But the Bṛhajjātaka[17] itself became the model for much of the subsequent Sanskrit literature on *jātaka*, and remains the most authoritative text-book on

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[8] CESS A 4.
[9] CESS A 4.
[10] CESS A 4. See also BJ 12, 2.
[11] CESS A 3, 121 b.
[12] CESS A 3, 46 b. Viṣṇugupta is **also cited in BJ 21, 3.**
[13] CESS A 3, 70 a.
[14] CESS A 4.
[15] CESS A 4.
[16] CESS A 4.
[17] Published Calcutta [1812 ?]; with Bhaṭṭotpala's *ṭīkā*, Kāśī 1861, Bombay 1863, and Bombay 1864; with a Telugu *ṭīkā* by S. T. Ācārya and V. R. Ācārya, Madras 1865, Madras 1872, and Madras 1885; with Bhaṭṭotpala's *ṭīkā*, Madras 1870, Madras 1873, and Bombay 1874; with Bhaṭṭotpala's *ṭīkā* and a Marāṭhī translation, Bombay 1874; with Mahīdhara's *ṭīkā*, Lucknow 1879, Lucknow 1882, and Lucknow 1887; with Bhaṭṭotpala's *ṭīkā*, Bombay 1882; with a Kannaḍa *ṭīkā*, Bangalore [1883]; with a Siṃhala *ṭīkā* by V. P. Baṇḍāra, Colombo 1888; with Mahīdhara's *ṭīkā* and a Hindi translation, Benares 1889; with the Hindī *ṭīkā* of Ādityadāsa, Delhi 1890; *adhyāyas* 1—5 with a Malayālam translation and commentary, Trichur 1890; with Bhaṭṭotpala's *ṭīkā* and a Bengālī commentary, Aruṇodaya 1893; with a Siṃhala translation by A. J. Wikramasinha, Colombo 1896; *adhyāyas* 1—10 with Govinda Somayājin's commentary, Palghat 1905; with a Marāṭhī translation, Belgaum 1910; with an English translation by H. P. Chatterjee, Allahabad 1912, reprinted New York 1974; *adhyāyas* 1—10 with the *ṭīkā*, Naukā, Bombay 1912; *adhyāyas* 1—20 with a Kannaḍa translation and commentary by B. V. Subrahmaṇya Śarman, Bangalore 1913; with the Telugu version of A. Vāsudeva Śāstri, Madras 1914; with the Kannaḍa translation of R. Veṅkaṭarāma Śāstri, Bangalore 1915; with Bhaṭṭotpala's *ṭīkā*, Madras 1916; with the Kannaḍa version of H. Sūrya Śāstri, Mysore 1917; with the Hindī *ṭīkā* of Mātṛprasāda Pāṇḍeya, Benares 1922; with the Telugu commentary of B. Veṅkaṭaraṅga Kavi, Madras 1923; edited with Bhaṭṭotpala's *ṭīkā* by Sītārāma Jhā, Benares 1923, reprinted Benares 1934; with the Telugu *ṭīkā* of A. Veṅkaṭakṛṣṇayya, Madras 1926; edited with the *vivaraṇa* of Rudra by K. Sāmba Siva Śāstrī as TSS 91, Trivandrum 1926, 2nd ed. by S. K. Pillai, Trivandrum 1957; edited with Bhaṭṭotpala's *ṭīkā* by G. S. Devasthalī, Benares and Bombay 1926; with the Tamil version of Viśvanāthārya, Madras 1927; with an English translation by V. Subrahmanya Sastri, Mysore 1929, 2nd ed. Bangalore 1971; edited with a Hindī *ṭīkā* by Sītārāma Jhā as MM 176, Benares 1944, 2nd ed. 1952; edited with a Hindī *ṭīkā* by Acyutānanda Jhā as HSS 171, Benares 1945, 2nd ed. Benares 1957; *adhyāyas* 1—10 edited with his own *ṭīkā* by A. N. Srinivasaraghava Aiyan-

the subject today. Again, most of its contents correspond to those of the YJ dan VYJ:

1. *rāśiprabheda*. YJ 1; VYJ 1.
2. *grahayoniprabheda*. YJ 1; VYJ 2.
3. *viyonijanma*. Cf. YJ 62, but the births of animals and plants is not a special topic for Sphujidhvaja or Mīnarāja.
4. *niṣeka*. YJ 5; VYJ 3.
5. *janmavidhi*. YJ 6; VYJ 4.
6. *ariṣṭa*. YJ 38.
7. *āyurdāya*. YJ 37; VYJ 5.
8. *daśāntardaśā*. YJ 39–41; VYJ 6–7.
9. *aṣṭakavarga*. YJ 44–50; VYJ 8.
10. *karmajīva*. Cf. YJ 25, 20–23, though again, the profession of the native is not a special topic for Sphujidhvaja or Mīnarāja.
11. *rājayoga*. YJ 8–9; VYJ 57.
12. *nābhasayoga*. YJ 36; VYJ 40 and 52–53.
13. *candrayoga*. YJ 10; VYJ 37–39.
14. *dvigrahayoga*. YJ 21.
15. *pravrajyāyoga*. YJ 22.
16. *ṛkṣaśīla*. Not in YJ; VYJ 63.
17. *candrarāśiśīla*. YJ 18; VYJ 18.
18. *rāśiśīla*. YJ 12–17; VYJ 17 and 19–23.
19. *dṛṣṭiphala*. YJ 32; cf. VYJ 9–15.
20. *bhāva*. YJ 20; VYJ 16.
21. *āśrayayoga*. YJ 8, 1–22; scattered in VYJ.
22. *prakīrṇa*. Some of this miscellaneous material is in YJ 1.
23. *aniṣṭa*. Congenital defects are not a separate topic for either Sphujidhvaja or Mīnarāja.
24. *strījātaka*. Not in YJ; VYJ 58–62.
25. *nairyāṇika*. YJ 42–43.
26. *naṣṭajātaka*. YJ 52, 1–5.
27. *dreṣkāṇa*. YJ 2–3.

The best commentary on the BJ or any other *jātaka* work is the Jagaccandrikā composed by Bhaṭṭotpala in Kāśmīra in ca. 967/969. Other commentators include Rudra, who wrote the Naukā in Kerala in 1527; Mahīdhara,[18] who

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GAR as ALS 79, Madras 1951; and edited with the *ṭīkā* of Parameśvara by K. RAGHAVAN PILLAI as TSS 198, Trivandrum 1962. In addition to the translations mentioned above there are a Pāli version published with a Burmese translation, 3 vols., Mandalay 1908–1909; an English translation by N. C. IYER, Madras 1885, 2nd ed. Madras 1905, 3rd ed. Madras 1926; and another English translation by B. SURYANARAIN ROW, Bangalore 1919, 3rd ed. 1948.

[18] CESS A4.

composed his *vivaraṇa* at Vārāṇasī in 1599; Kṛṣṇa,[19] Gadādhara Miśra,[20] and two Parameśvaras (Jātakacandrikā[21] and Horābhiprāyanirṇaya).[22] Both Rudra and Mahīdhara have copied out much of the Jagaccandrikā.

Varāhamihira also wrote a summary of the BJ, the Laghujātaka,[23] in sixteen *adhyāyas*. There is the inevitable commentary, the Śiṣyahitā, written by Bhaṭṭotpala in Kāśmīra in 966; there are also commentaries composed by Maheśvara,[24] the father of Bhāskara, in the Sahyādri in ca. 1100; by Ananta[25] in 1534; and by Īśvaramiśra[26] (Dīpikā).

At some time after 600 was written the *pūrvakhaṇḍa* of what was to become known as the Bṛhatpārāśarahorā[27] ascribed to Parāśara.[28] It computes the *ayanāṃśa* or precession, due to a misunderstanding of Āryabhaṭa, from 522 (BPH *pūrva* 3, 31), and is deeply indebted to the BJ; it also has borrowed two verses from Sphujidhvaja (BPH *pūrva* 2, 47–48 equal YJ 1, 59–60). Moreover, it was used by Kalyāṇavarman, who wrote in ca. 800 (BPH *pūrva* 2, 49–52 = S 5, 21–24; and BPH *pūrva* 21, 17–48 equal S 21, 21–52; cf. S 21, 6), and its existence is presupposed by the author of the *uttarakhaṇḍa*, which was commented on by Govindasvāmin in ca. 850. Therefore, the *pūrvakhaṇḍa* must have been written between ca. 600 and 750, and the *uttarakhaṇḍa* after the *pūrvakhaṇḍa* but before ca. 800. The *pūrvakhaṇḍa* in fifty-one *adhyāyas* is a rich but confused collection of material, much of which is unprecedented: the basic

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[19] CESS A 3, 22b.

[20] CESS A 2, 114b.

[21] CESS A 4.

[22] CESS A 4.

[23] Published with Bhaṭṭotpala's *ṭīkā*, Ratnāgiri 1867; *adhyāyas* 3–12 edited by H. Jacobi, De Astrologiae Indicae "Horā" appellatae originibus, Bonn 1872, reprinted Bonn 1896; published with the Hindī *ṭīkā* of Mathurānātha, Lucknow 1875; with Bhaṭṭotpala's *ṭīkā*, Bombay 1883; with the Siṃhalese translation of O. A. A. Jayasekere, Colombo 1886; with Bhaṭṭotpala's *ṭīkā* and the Bengālī translation of Rajanīkānta Ācārya, Calcutta 1910; with Bhaṭṭotpala's *ṭīkā* and the Hindī commentary of Nārāyaṇaprasāda, Bombay 1911; with Bhaṭṭotpala's *ṭīkā* and the Hindī commentary of Cirañjīva Śarman, Benares 1921; with the Hindī *ṭīkā* of Kāśīrāma Pāṭhaka, Bombay 1936; with the Sanskrit and Hindī *ṭīkās* of Sītārāma Jhā as MM 72, Kāśī 1948; with the Gujarātī *ṭīkā* of Bhānuśaṅkara Nīlakaṇṭha Ācārya, Bhāvanagara 1953; and with Bhaṭṭotpala's *ṭīkā* and the Hindī commentary of Vāsudeva, Vārāṇasī 1968.

[24] CESS A 4.

[25] CESS A 1, 40b.

[26] CESS A 1, 56a–56b.

[27] Edited by Giridhara Lāla Śarman *(pūrva)* and Govinda Śarman *(uttara* with Śrīdhara's *ṭīkā)*, Bombay 1905, 2nd ed. Bombay 1915, and 3rd ed. Bombay 1951; with a Bengālī version by Ṭhākuradāsa Cūḍāmaṇi, Calcutta 1926; with a Hindī *ṭīkā* by Sītārāma Jhā as MM 189, 2nd ed. Kāśī 1952, and 3rd ed. Vārāṇasī 1968; with a Hindī *ṭīkā* by Gaṇeśadatta Pāṭhaka, Vārāṇasī [1972]; and with a Hindī *ṭīkā* by Devacandra Jhā as KSS 220, Vārāṇasī 1973. There is an English translation by N. N. Krishna Rau and V. B. Choudhari, 2 vols., Bombay 1963.

[28] CESS A 4.

elements of astrology (2–3); aspects (4); the nature of the neonate native (5–7); the planetary operators *(kāraka)* (8–9); the astrological places (10); the mounted places *(ārūḍha)* and their next places *(upapada)* (11–12); the killer *(māraka)* planets (13); the astrological places and their lords (14–15); curses in previous incarnations *(pūrvajanmaśāpa)* (16); *aṣṭakavarga* (15–20); *nābhasa* and other *yogas* (21–22); smashing the killer planet *(mārakabheda)* (23); *āyurdāya* (24–25); death (26–27); *rājayogas* and *yogas* leading to wealth and poverty (28–31); rebirths (32); pleasure and sorrow (33); various conditions *(avasthās)* of the planets (34); the varieties of *daśās*, including *viṃśottarī*, *ṣoḍaśottarī*, *dvādaśottarī*, *aṣṭottarī*, *pañcottarī*, *śatābdikā*, *caturaśītyabdikā*, *dvisaptatikā*, *ṣaṣṭihāyanī*, and *ṣaṭtriṃśatkā* (35);[29] *viṃśottarīdaśās* (36); *antardaśās* and their subdivisions: *upadaśās*, *sūkṣmadaśās*, and *prāṇadaśās* (37–48); *kālacakradaśās* (49); *caradaśās* (50); and the *sudarśanacakra* (51).

This congeries seems to consist of an original core, characterized by its being cast in the form of a dialogue between Maitreya and Parāśara, and various accretions. These latter may include: *adhyāyas* 5–6, 13–14, and 17–23, which are not dialogues and contain no vocatives; *adhyāya* 16, which is in the form of a dialogue between Pārvatī and Śaṅkara; *adhyāya* 33, which is in the form of a dialogue between Sujanma and Lomaśa; *adhyāyas* 36–48, which are spoken by Parāśara for the benefit of Maheśvara; and *adhyāyas* 49–51, which are attributed to Pārvatī. The elimination of at least *adhyāyas* 16, 33, and 49–51 would produce a more homogeneous text; but the precise extent of the *pūrvakhaṇḍa* must await a careful study of the manuscripts and of its relation to other texts—not only to the *uttarakhaṇḍa* and to Kalyāṇavarman, but also to Bhaṭṭotpala's *ṭīkā* on the BJ from which some of its verses seem to be derived.

The *uttarakhaṇḍa*, which is also a dialogue between Maitreya and Parāśara, is a much more unified composition, and its integrity is guaranteed by Govindasvāmin's commentary. It deals with *aṣṭakavarga* (1; cf. *pūrva* 17–23), the six kinds of planetary strength *(ṣaḍbala)* (2); computing planetary strength *(iṣṭakaṣṭavarṇana)* (3); *raśmi* (4; cf. VYJ 56); the native's passage through this world *(lokayātrā)* (5–9); *āyurdāya* (10–12; cf. *pūrva* 24–25); good fortune *(bhāgya)* (13); time units and the fruition of astrological indications (14–17); interrogations *(praśna)* (18); and, in conclusion, a table of contents (19) and a praise of the work (20). The *uttarakhaṇḍa* was commented on by Govindasvāmin in Kerala in about 850 (Prakaṭārthadīpikā), while the whole BPH was commented on by Śrīdhara and Harikṛṣṇa at Jayapura in about 1875. Despite the questionability of the authenticity of some parts of the *pūrvakhaṇḍa*, the BPH represents some notable developments in the long process by which the original Hellenistic astrology that was transmitted to India in the second century was made increasingly complex so as to generate predictions more closely approximating reality; these developments are particularly noticeable in the theories of *āyurdāya.daśās*, and the computation of planetary strength.

[29] See D. Pingree, The Yavanajātaka of Sphujidhvaja, vol. 2, p. 336.

A more traditional work, but one of great importance, is the Sārāvalī[30] composed by Kalyāṇavarman,[31] the lord of Vyāghrapadi (Vyāghrataṭī in Bengal), in about 800. Its fifty-four chapters are to a large extent based on the YJ, the VYJ, the BJ, and the BPH,[32] though Kalyāṇavarman also quotes (in addition to many astrologers whom we have already mentioned) Citragupta[33] (S 54, 12), Cūḍāmaṇi[34] (S 5, 20 and 39, 8), Devakīrti[35] (S 37, 1), Brahmaśaṇḍa[36] (S 10, 6), who had previously been cited by Varāhamihira (BY 9, 1), and Hari (S 5, 2; 6, 1; and 6, 6). But most important for his date is his mention of Kanaka[37] (S 53, 1), who is probably identical with the Kanaka who served as an astrologer in the court of Hārūn al-Rashīd (786–809) in Baghdād and continued to work in Baghdād into the reign of al-Ma'mūn (813–833);[38] he was probably still in India till sometime in the 790's. Other Indian astrologers known to the Arabs during the 'Abbāsid period include Āryakula,[39] Indra,[40] Ṛṣi,[41] Jitāri,[42] Jina,[43] Rāja, Saṅghadhāra, and Siṅghala. The S itself was known to al-Bīrūnī (India 14).

If Kalyāṇavarman's terminus post quem is given by his use of the BPH and his reference to Kanaka, his terminus ante quem is established by the quotations from the S in Govindasvāmin's Prakaṭārthadīpikā, which was written in Kerala in about 850. This commentary on the *uttarakhaṇḍa* of the BPH is extraordinarily rich in quotations from early astrologers, astronomers, and mathematicians; aside from those astrologers already discussed, Govindasvāmin cites

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[30] Edited by K. Śrīnivāsa Tirumalācārya, 2 (3?) vols., Kalpatti and Palghat 1906–1909; by V. Subrahmaṇya Śāstrī, Bombay 1907, 2nd ed. Bombay 1914, and 3rd ed. Bombay 1928; with a Telugu translation, Madras 1923; and edited with the Hindī *ṭīkā* of Sītārāma Jhā by Prahlāda Svāmin as MM 229, Benares 1953. Adhyāya 45, the Strījātaka, was published with a Telugu version at Madras in 1885 and 1926. The Sārāvalī was translated into English by N. N. Krishna Rau and V. B. Choudhari, [Bombay 1961]; the Strījātaka was translated by R. K. Aiyar, "Stri Jathakam or Female Horoscopy," The Astrological Magazine 5–10 (1901–1908).

[31] CESS A 2, 26a–29a; A 3, 19a; ans A 4.

[32] Kalyāṇavarman acknowledges his indebtedness to Varāhamihira and Yavanarendra (Sphujidhvaja) in S 1, 2–3; further details will be found in the commentary to the YJ.

[33] CESS A 3, 47a.

[34] CESS A 3, 52b.

[35] CESS A 3, 118a.

[36] CESS A 4.

[37] CESS A 2, 19a–19b.

[38] D. Pingree in DSB 7, New York 1973, pp. 222–224. See also D. Pingree, "The 'Liber Universus' of 'Umar ibn al-Farrukhān al-Ṭabarī," JHAS 1 (1977), 8–12.

[39] CESS A 1, 50b.

[40] CESS A 1, 55a.

[41] CESS A 1, 59a.

[42] CESS A 3, 65a.

[43] CESS A 3, 65a.

Kṛṣṇa[44] (who may be identical with the author of the Kṛṣṇīya or Cintājñāna[45] which was extremely popular in Kerala), Bhagadatta,[46] Cirantana Yavana, Yavaneśvara (who is different from Sphujidhvaja, though the latter is also quoted by Govindasvāmin), and Haridatta (the seventh century astronomer, who evidently also wrote on astrology). The names of and quotations from the works of a few more authorities on *jātaka* from this early period can be found in Bhaṭṭotpala's Jagaccandrikā; they are Yama (on BJ 8, 3), Vaṅkālaka[47] (on BJ 15, 1), and Śrutakīrti (on BJ 1, 7; 8, 9; 13, 3; and 21, 3).

At some time before Śrīpati (fl. 1039–1056) wrote his Jātakakarmapaddhati[48] in Rohiṇīkhaṇḍa, Śrīdhara had written on *jātaka* (see JKP 5, 36). There does exist in several manuscripts, some of which are associated with Mysore (the earliest dated example was copied in 1589), a Jātakapaddhati of Śrīdhara; and a Jaina priest named Śrīdhara from Narigunda in the Karṇāṭaka wrote, in Kannaḍa, a Jātakatilaka[49] in 1049 under the Western Cālukya Someśvara I (1042–1068). What relation the two Śrīdharas might have to each other or to the astrologer cited by Śrīpati remains unclear. Śrīpati's own Jātakapaddhati or Jātakakarmapaddhati teaches in eight *adhyāyas* how to calculate the astrological places, and how to compute the amount of aspects, the strengths of the planets, the length of life, the *daśās* and *antardaśās*, and the *aṣṭakavarga;* it is closely related to the *pūrvakhaṇḍa* of the BPH. The JKP was immensely influential as is indicated by the numerous imitations of it and commentaries on it; the latter were composed by Sūryadeva at Gaṅgāpura in about 1250 (Jātakālaṅkāra); by Parameśvara at Aśvatthagrāma in about 1425 (Bālaprabodhinī); by Acyuta in about 1525 (Bhāvārthamañjarī); by Sūryadāsa at Pārthapura in about 1550 (Bodhasudhākara); by Raghunātha (the unique manuscript was copied in 1612); by Sumatiharṣa Gaṇi, presumably at Khairābād, in 1616 (Subodhā); by Kṛṣṇa in about 1625; by Dullaha[50] in 1776; and by Kāmābhaṭṭa[51] (Sampradāyapariśuddhi); by a Brāhmaṇa from Parakroḍa in

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[44] CESS A 2, 50a.

[45] CESS A 2, 50a–51a.

[46] CESS A 4.

[47] Vaṅkālaka was already quoted in the Kuvalayamālā completed by Uddyotana Sūri at Jalor in Rājasthān in 779; see A. N. Upadhye, "Vaṅkālakācārya. A Forgotten Authority on Astrology," Professor P. K. Gode Commemoration Volume, POS 93, Poona 1960, pt. III, pp. 203–208, and "Works and Authors Referred to in the Kuvalayamālā of Uddyotanasūri," VIJ 3 (1965), 117–119.

[48] Edited with an English translation by V. Subrahmanya Sastri, Bangalore 1903, 2nd ed. Bangalore 1919, 3rd ed. Bangalore 1937, and 4th ed. Bangalore 1957; and edited with the commentary of Kṛṣṇa by J. B. Chaudhuri, PST 19, Calcutta 1955.

[49] Edited with a Kannaḍa *ṭīkā* by S. N. Kṛṣṇa Jyotiṣa as PKG 22, Mysore 1959.

[50] CESS A 3, 117a.

[51] CESS A 2, 31b.

Kerala;[52] by Bhāveśa;[53] by Bhāskara;[54] by Bhūdhara;[55] by Mādhava[56] (Janabodhinī); and by Śivadāsa.

In 1167, during the reign of the Caulukya Kumārapāla (ca. 1143—1172), at Campāvatī (presumably Chātsu south of Jayapura in Rājasthān rather than Chaul south of Bombay in the Koṅkaṇa), a Jaina of the Kāśahradagaccha, Naracandropādhyāya[57] wrote a Beḍājātaka,[58] which is a *vṛtti* in verse on his own Janmasamudra. In eight *kallolas* it treats the astrology of conception, birth, congenital faults, death, *rājayogas*, other *yogas*, and *strījātaka*.

There circulates, primarily in South India, an extensive work on *jātaka* entitled Horāsāra,[59] which is sometimes attributed to Varāhamihira's son, Pṛthuyaśas. However, the author has borrowed verses from Kalyāṇavarman's Sārāvalī[60] and so must have written after ca. 850; and the H is cited by Viṣṇuśarman[61] (fl. ca. 1370), and so must have been written before ca. 1350. The H is also closely related (as is the S) to the southern Candrābharaṇahorā of Yavana,[62] but unfortunately the date of that work is not yet precisely known. The H consists of thirty-two *adhyāyas* covering basically the material in the BJ with the addition of one chapter (31) on *uḍudaśā*, which computes the planetary *daśās* from the *nakṣatras*, and one on omens (32). On *uḍudaśā* there also exists a popular Uḍudāyapradīpa[63] based on Parāśara[64] (cf. BPH *pūrva* 35, 71—74).

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[52] CESS A 4.
[53] CESS A 4.
[54] CESS A 4.
[55] CESS A 4.
[56] CESS A 4.
[57] CESS A 3, 136a—137a, and A 4.
[58] Edited with a Hindī *ṭīkā* by G. K. Ojhā, Triphalā, Vārāṇasī 1971, pp. 159—271.
[59] Edited with an English translation by V. Subrahmanya Sastri and M. R. Bhat, Bangalore 1949.
[60] I find the following coincidences:

H	S	H	S
5, 38	10, 25	20, 16a—b	35, 107a—b
8, 8a—b	40, 9a—b	20, 17a—b	35, 150a—b
8, 9	40, 21	20, 19	35, 165
8, 14—16	40, 12—14	20, 20	35, 168
8, 17—18	40, 17—18	20, 24c—25b	35, 138
20, 12a—13b	35, 145a—145b	27, 7c—8d	51, 1a—2b
20, 14a—b	35, 114a—b	27, 11a—12b	51, 2c—3d
20, 15	35, 110		

[61] H 17, 59a on VM 8, 2 (vol. 2, p. 135) and 17, 94b—97a on VM 4, 28 (vol. 1, p. 293).
[62] D. Pingree, The Yavanajātaka, vol. 1, pp. 28—31.
[63] Published Calcutta [n d]; with the Hindī *ṭīkā* of Govindarāma, [NP] 1859 and 1868; Bombay 1870; with a Hindī *ṭīkā* Bombay 1870, Bonares 1872, Delhi 1874, and Lucknow 1874; Bombay 1875; with the *ṭīkā* of Bhairavadatta, Calcutta 1883; edited with a Siṃhalese *ṭīkā* by D. Fernando, Colombo 1888; with a Hindī *ṭīkā*, Agra 1889; with Bhairavadatta's *ṭīkā* in Bṛhaspati 1 (1891—97); edited with a Telugu *ṭīkā*

On the same subject and called by the same title or by the title Jātakacandrikā[65] is a short poem by Veṅkaṭeśvara, who was the grandson of Govinda Dīkṣita,[66] the court astrologer of Acyutappa Nāyaka (1560—1600) at Tanjore. Veṅkaṭeśvara has apparently borrowed several verses from the older Uḍudāyapradīpa.

Possibly somewhat later than the H is the Horāmakaranda[67] written by Guṇākara[68] at Kharjūra in Avanti. This work in thirty-one *adhyāyas* closely follows the BJ. Since Guṇākara mentions the RM composed by Bhojarāja in 1042 (HM 1, 5), and since the HM itself is often quoted by Śivarāja (ca. 1475/1500) in his Jyotirnibandha, he must have lived between ca. 1100 and 1450.

Also quoted by Śivarāja is the Lomaśasaṃhitā,[69] which is basically a dialogue between Lomaśa and Sujanma, though some sections are dialogues between Śiva and Pārvatī; BPH *pūrva* 33 is a dialogue between the first pair of interlocutors. In general the Lomaśa seems to belong to the tradition of the BPH.

Vaidyanātha wrote in South India a Jātakapārijāta[70] in eighteen *adhyāyas* largely based on the S of Kalyāṇavarman,[71] though he has also taken many

by K. Subbarayarya, Madras 1898; with Madanamohana Pāṭhaka's Hindī translation, Lucknow 1906; with a *ṭīkā*, Amalapuram 1907; edited with a *ṭīkā* and Oriya translation by C. Praharāja, 3rd ed., Cuttack 1910; edited with a Marāṭhī translation by V. G. Navāthe, Jātakaśiromaṇi 1, 7, Bombay 1914; edited with Sanskrit and Hindī *ṭīkās* by Mātṛprasāda Pāṇḍeya, Benares 1924; edited with a *ṭīkā* and a Hindī translation by Acyutānanda Jhā as HSS 135, Benares 1941, 2nd ed. Benares 1948; edited with a Hindī *ṭīkā* by Sītārāma Jhā as MM 19, 3rd ed., Benares 1945; edited with a Hindī *ṭīkā* by D. R. Kapūra, Vārāṇasī 1964; and edited with Sanskrit and Hindī *ṭīkās* by Vāsudeva Gupta, Vārāṇasī 1972.

[64] CESS A 4.

[65] Published with a Telugu *ṭīkā*, Madras 1863, 2nd ed. Madras 1873: published with an English translation and notes by B. Suryanarain Rao, Bellary 1898, 2nd ed. Madras 1900, 3rd ed. (without Sanskrit text, as are the subsequent editions) Madras 1908, 6th ed. Bangalore [1976]; and with a Telugu *ṭīkā*, Madras 1912 and 1919.

[66] CESS A 2, 137b.

[67] Published Lucknow 1879.

[68] CESS A 2, 127b—128b; A 3, 31b; and A 4.

[69] I have used G 8442 of the Asiatic Society of Bengal and transcripts of 9488, 9489, and 9490 of the Scindia Oriental Institute, Ujjayinī.

[70] *Adhyāyas* 1—2 with an English translation by V. Subrahmanya Sastri, Bombay 1903; the whole by the same, Bangalore 1915, and in 2 vols. Bangalore 1932—1933; with a Gujarātī translation, Ahmedabad 1917; with a Tamil version, Madras 1919; and edited with Kapileśvara Śāstrin's *ṭīkā* by Mātṛprasāda Śāstrin as KSS 10, Benares [1942], 3rd ed. Benares 1953.

[71] I have noted, e.g., the following borrowings:

JPJ	S	JPJ	S
5, 72	46, 22	7, 37	35, 89
5, 79	46, 19	7, 38	35, 117
7, 32	35, 32	7, 39	35, 126
7, 33	35, 49	15, 24	20, 5
7, 35	35, 83	15, 26—39	20, 6—19
7, 36	35, 86		

verses from the BJ[72] and even from the H.[73] In general, his astrology seems more developed than that of Śrīpati; but a more exhaustive search of the relevant texts is necessary before one can establish a firm terminus post quem for the JPJ; the terminus ante, ca. 1450, is provided by the quotations in Śivarāja's Jyotirnibandha. At some time after Vaidyanātha, whose work he uses,[74] Mantreśvara[75] wrote a Phaladīpikā[76] at Śrīśālivāṭī (Tinnevelly). In twenty-eight *adhyāyas* he covers the main topics of *jātaka; adhyāya* 24 describes the *aṣṭakavarga* of Horāsāra 17.

In about 1500 at Nandigrāma in Gujarāt Keśava,[77] the father of the celebrated Gaṇeśa, composed an extremely concise (there are only forty-two verses) but very popular handbook on the principal mathematical calculations essential in *jātaka*, the Jātakapaddhati.[78] Keśava's inspiration was apparently Śrīpati's JKP, of which his JP might be regarded as a condensation. Commentaries were

[72] E.g.:

JPJ	BJ	JPJ	BJ
3, 11	4, 1	5, 17—21	7, 9—13
3, 76—79	5, 23—26	7, 56	21, 2
4, 17	4, 16	7, 83—85	13, 3 and 5—6
4, 18	4, 10	7, 166—177	12, 2—5, 7—11, and 13—15
4, 32—39	6, 3—6 and 9—12	15, 23	15, 4
4, 99	7, 14	15, 42	15, 2
5, 7	7, 2	18, 12	8, 20
5, 9	7, 3	18, 13	8, 22
5, 11	7, 4	18, 14	8, 10

[73] E.g., JPJ 5, 80—81 equal H 26, 37—38.

[74] E.g.:

PhD	JPJ	PhD	JPJ
13, 3—4 and 6	4, 1—3	19, 18	18, 60
19, 9	18, 84	19, 19	18, 73
19, 16	18, 107	19, 23	18, 123

[75] CESS A 4.

[76] Edited by Kṛṣṇa Sūri, Kumbakonam [1898]; published Kalpatti [1905]; Madras 1914; with Viśvanāthācārya's Tamil version, Madras 1928; edited by Gaṇapati Sarakāra, Calcutta 1934; published with an English translation by V. Subrahmanya Sastri, Bangalore 1937, 2nd ed. Bangalore 1950; and with a Hindī *ṭīkā* by G. K. Ojhā, Vārāṇasī 1969. *Adhyāyas* 20—28 were published Palghat [1906].

[77] CESS A 2, 66b—70b; A 3, 24a; and A 4.

[78] Published with a Marāṭhī version, Bombay 1872; with a Hindī *ṭīkā*, Benares 1877; with Divākara's *ṭīkā*, Benares 1882; with Umāśaṅkara Miśra's Sanskrit and Hindī *ṭīkās*, Kāśī 1890; with Jagadīśaprasāda Tripāṭhin's Hindī *ṭīkā*, Bombay 1899, 2nd ed. Bombay 1924; with the Gujarātī translation and *ṭīkā* of K. M. Dvivedin, Bombay 1909; with the *ṭīkā* of Gopīkānta Śarman, Ayodhyā 1924; and edited with the *ṭīkās* of Apūcha Jhā, Rāmādhīna Śarman, and himself by Sītārāma Jhā, Benares 1925, 2nd ed. as MM 3, Benares 1948.

composed by Keśava himself; by Viśvanātha at Kāśī in 1618; by Divākara at Kāśī in 1626 (Prauḍhamanoramā[79]); by Dharmeśvara[80] in the first half of the seventeenth century in Mālava (Vāsanābhāṣya); by Nārāyaṇa at Kāśī in 1678 (Jātakakaustubha); and by Gurudāsa[81] at Jālandhara in 1824.

Another extremely popular work on *jātaka*, though this time a very full treatment of the subject in some forty-five *adhyāyas*, is the Jātakābharaṇa[82] composed by Ḍhuṇḍhirāja,[83] the pupil and (probably) nephew of Jñānarāja, at Pārthapura in about 1525. Another sixteenth century astrologer was Nārāyaṇa Bhaṭṭa.[84] He wrote another extremely popular work, the Camatkāracintāmaṇi,[85] which, in 115 verses, gives predictions based on the presence in each of the twelve astrological places of each of the nine planets. The earliest dated manuscript was copied in 1596. There is a commentary, Anvayārthadīpikā, composed by Dharmeśvara in the first half of the seventeenth century. A similar work, also entitled Camatkāracintāmaṇi, was written by Rājarṣi at Dadhīcyapura in Gujarāt in about 1630.

The year before Divākara wrote his Prauḍhamanoramā on Keśava's Jātakapaddhati—that is, in 1625—he composed a similar, but lengthier, treatise entitled Jātakamārgapadma,[86] in which he claims to present the essence of the *tantras* of Śrīpati, Keśava, and Sundara. Divākara wrote his own commentary on this, the Gaṇitatattvacintāmaṇi, in 1627.

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[79] T. AUFRECHT, "Ueber die Prauḍhamanoramā von Divākara," ZDMG 45 (1891), 303–304.

[80] CESS A 3, 126a–127a, and A 4.

[81] CESS A 3, 128b–129a.

[82] Published Bombay 1861 and 1888; Delhi 1875; Lucknow 1879 and 1889; Poona 1883; Calcutta 1884, 1885, and 1886/7; with the Hindī *ṭīkā* of SŪRYANĀRĀYAṆA SIDDHĀNTIN, Lucknow 1900; with the Hindī *ṭīkā* of VANAMĀLĪ CATURVEDĪ, Bombay 1903; with the Hindī *ṭīkā* of ŚYĀMALĀLA, Bombay 1905; with the Siṃhala translation of M. KHEMĀNANDA, Colombo 1913; with the Marāṭhī version of M. B. GOḌABOLE, Poona 1918; edited by V. TĀTĀCĀRYA, Pemtapāḍu 1929; with a Hindī *ṭīkā* by ACYUTĀNANDA JHĀ as HSS 212, Benares 1951; and with a Hindī *ṭīkā* by SĪTĀRĀMA JHĀ, Benares [ND].

[83] CESS A 3, 79b–84b, and A 4.

[84] CESS A 3, 152b–155b, and A 4.

[85] Published with the *ṭīkā* of Dharmeśvara, Benares 1856, 1869, and 1870; with a Marāṭhī version, 2nd ed., Poona 1869; with Dharmeśvara's *ṭīkā*, Delhi 1872 and 1876 and Calcutta 1883; with the Siṃhala translation of H. D. F. TAMBI-APPU GURUNNĀNSE, [Colombo] 1891; with the Bengālī translation of RĀMAGOPĀLA JYOTIRVINODA, Calcutta 1895; with the Marāṭhī version of M. B. GOḌABOLE, Poona 1915; with the Hindī version of MADANAMOHANA PĀṬHAKA, Benares 1916, Bombay 1919, and Benares 1924, and also with the Bengālī translation of SURENDRANĀTHA BHAṬṬĀCĀRYA, 2nd ed., Calcutta 1936; edited with a Hindī *ṭīkā* by GAṆAPATIDEVA ŚĀSTRIN as HSS 45, Benares 1935, 2nd ed. Benares 1948, and 3rd ed. Benares 1963; edited by GAṆEŚADATTA PĀṬHAKA, Benares 1966; and edited with Dharmeśvara's *ṭīkā* by BRAJAVIHĀRĪ LĀLA ŚARMĀ. Vārāṇasī 1975. English translation by KṚṢṆANĀTHA RAGHUNĀTHAJĪ published Bombay 1894.

[86] I have used Smith Indic 104 at Columbia University.

In the early seventeenth century a popular treatise on selected topics of *jātaka* was penned by Gaṇeśa,[87] who wrote his Jātakālaṅkāra[88] at Bradhnapura on the Tāpī in Gujarāt in 1613; he states that he is following the Śukajātaka. There are commentaries written by Haribhānu Śukla in 1809; and by Kṛpārāma[89] and Narmadāgiri Avadhūta.[90]

In 1629 one Harajī or Harijit wrote a Yoginīdaśāphalaprakaraṇa describing the eight *yoginīdaśās* in accordance with the Śivayāmala. And in 1633 Rājarṣi, the son of Kalyāṇa, wrote a Daśācintāmaṇi at Dadhīcyapura in Gujarāt; he also was the author of a Yoginīdaśāphala. To a Kalyāṇa,[91] who may be Rājarṣi's father, is attributed a vast Janmapatrikāpaddhati, which is sometimes also entitled Mānasāgarī; and to Mānasāgara[92] is ascribed an identical—or at least very similar—Mānasāgarī,[93] in which is incorporated Harajī's Yoginīdaśāphalaprakaraṇa (end of *adhyāya* 5). The earliest dated manuscript of the Mānasāgara version was copied in 1708. Manuscripts of Kalyāṇa's version seem to have quotations from the VYJ, the BJ, the LJ, and other works. The relations of the various Mānasāgarīs and the various Yoginīdaśās to each other remain to be investigated.

In about 1625 Nṛsiṃha[94] put together a vast *nibandha* entitled Jātakasāra-

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[87] CESS A 2, 110a—114a; A 3, 28b; and A 4.

[88] Published Calcutta [1812 ?]; with a *ṭīkā*, Benares 1858; with Haribhānu's *ṭīkā*, Benares 1869 and Bombay 1871; with Ātmarāma Kāśīnātha Śāstrī's Marāṭhī translation, Bombay 1873; with Haribhānu's *ṭīkā*, Bombay 1876, Lucknow 1879, and Bombay 1889; with a Siṃhala *ṭīkā*, [Colombo ?] 1882; with Haribhānu's *ṭīkā* and a Marāṭhī translation, 2nd ed. Poona 1894; with a Bengālī translation, Calcutta 1901; with Haribhānu's *ṭīkā* and the Hindī translation of Rāmanātha Śarman, Bombay 1902; with the Oriyā translation of Gopīnāthakara Śarman, 2nd ed. Cuttack 1908, reprinted Cuttack 1914 and 1920; with a Gujarātī *ṭīkā*, Bombay 1909; with the Marāṭhī translation of Viṣṇugopāla Navāthe Jātakaśiromaṇi 5, Bombay 1914; Madras 1915; with the Hindī *ṭīkā* of Rāmasvarūpa Śarman, Bombay 1916; with Haribhānu's *ṭīkā* and the Hindī *ṭīkā* of Sītārāma Śarman, Benares 1923; with Ādityanārāyaṇa Pāṇḍeya's Hindī *ṭīkā*, Benares [1925] and [1927]; with a Bengālī translation, Calcutta 1929; with Haribhānu's *ṭīkā* and Rāmeśvaradatta's Hindī *ṭīkā*, Benares 1930/31; with an English translation by V. Subrahmanya Sastri, Bangalore 1941; with Haribhānu's *ṭīkā* and Dīnānātha Jhā's Hindī *ṭīkā* as KSS 141, Benares 1950; edited by Gaṇeśadatta Pāṭhaka, Benares 1966; with a Marāṭhī translation by R. Paṭavardhana, Poona [ND]; and with a Hindī *ṭīkā* by H. Ś. Dātāra, Vārāṇasī [ND].

[89] CESS A 2, 47b.

[90] CESS A 3, 144a.

[91] CESS A 2, 25a—25b.

[92] CESS A 4.

[93] Published Bombay 1871, 1876, and 1903; with the Hindī translation of Vanamālī Caturveda, Bombay 1904; with the Hindī *ṭīkā* of Vaṃśīdhara, Bombay 1904, reprinted Bombay 1919; with the Hindī *ṭīkā* of Madhukānta Jhā, VSG 101, Vārāṇasī 1963; edited with the Hindī *ṭīkā* of Rūpanārāyaṇa Jhā by Sītārāma Jhā, Vārāṇasī [ND]; and with Sītārāma Jhā's own *ṭīkā* as MM 261, Benares 1966.

[94] CESS A 3, 198a—198b, and A 4.

dīpa.[95] The earliest dated manuscript was copied in 1637, and the latest work to which the author refers is the Saurabhāṣya composed by Nṛsiṃha at Vārāṇasī in 1611; whether or not the two Nṛsiṃha's are identical cannot as yet be established. Other authorities utilized in the JSD include the YJ, the VYJ, the BJ, the LJ, the S, the HM, and, from a later period, Dāmodara, the Gaurījātaka, the Sūryāruṇasaṃvāda, and works on *tājika* and *hillāja*. In 1654 Balabhadra[96] wrote another gigantic *nibandha*, the Horāratna,[97] at the court of Shāh Shujā'. Though so late, this is an extremely full and valuable compilation deserving of a critical edition and careful study for its contributions to the histories of the texts from which it has borrowed.

A far more original work is the Sarvārthacintāmaṇi,[98] composed by Veṅkaṭeśa near Tirupati in Tamilnadu in about 1650. The core of its eighteen chapters deals in great detail with the possible influences of the twelve *bhāvas* on the native's life (*adhyāyas* 2–8). There is a commentary ascribed to Divānanda[99] (or Divānacandra) Miśra or to his son, Rādhākṛṣṇa; both lived at Lavapura (Lahore, Panjāb).

At Jambūsara in Gujarāt Yājñikanātha composed the Jātakacandrikā,[100] which deals with technical aspects of *jātaka* in six *prabodhas*. By this time Kāśīnātha[101] had written his popular Lagnacandrikā;[102] for the oldest dated manuscript was copied in 1670. If, however, this Kāśīnātha is identical with the author of the Praśnapradīpa and the Śīghrabodha, as seems likely, he flourished before 1550. A rather traditional treatise on *jātaka* is the Śambhuhorāprakāśa[103] composed by Puñjarāja[104] in about 1700 for Śambhudāsa (born 1662), the ruler of Nandidvārapura (Nander, Mahārāṣṭra?). Several decades later Putumana Somayājin, the author of the Karaṇapaddhati, wrote the Jātakādeśamārga[105] in Kerala.

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[95] Edited with his own *ṭīkā* by Lakṣmīnārāyaṇa Upādhyāya as TSMS 45 = Madras GOS 64, Tanjore 1951.

[96] CESS A 4.

[97] I have used 1030 of 1886/92 at the Bhandarkar Oriental Research Institute in Poona. *Adhyāyas* 1—5 were published with his own Hindī *ṭīkā* by M. Caturvedī, Vārāṇasī 1979.

[98] Published Ratnāgiri 1842; Bombay 1876; and with the Hindī *ṭīkā* of Mahīdhara Śarman, Bombay 1905, reprinted Bombay 1955.

[99] CESS A 3, 112a.

[100] Edited with a Gujarātī translation by Gaurīśaṅkara Maṅchāśaṅkara Raikva, 3rd ed., Surata 1924.

[101] CESS A 2, 36b—39a; A 3, 20a; and A 4.

[102] Published Kāśī 1867; Delhi 1876; with the Hindī *ṭīkā* of Nārāyaṇaprasāda, Bombay 1916; with the Hindī *ṭīkā* of Rāma Vihāri Sukula, 13th ed., Lucknow 1968; and with the Hindī *ṭīkā* of Vāsudeva Gupta, Vārāṇasī [ND].

[103] Published Kāśī 1869; and with a Hindī *ṭīkā* by Mahīdhara Śarman, Bombay 1916, reprinted Bombay 1937.

[104] CESS A 4.

[105] Published Madras 1918; Kunnamkulam 1930; with an English translation by V. Subrahmanya Sastri and M. M. Bhat, Bangalore 1942; with a Malayālam *ṭīkā*

Before 1729 when the earliest dated manuscript was copied Jaimini[106] (or rather someone using the sage's name) composed the Upadeśasūtra,[107] a collection of 1031 *sūtras* (there is also a set of verse *kārikās* that summarize them) divided into four *adhyāyas*, each of which has four *pādas*. The only other *jātaka* work composed in *sūtras* seems to be the Jātakatattva[108] completed by Uḍumbara Mahādeva Pāṭhaka[109] at Ratnapura (Ratlam, Madhya Pradeśa) in 1872. The earliest manuscript of the Upadeśasūtra already contains the commentary of Kṛṣṇānanda Sarasvatī,[110] who calls himself a Drāviḍācārya; this commentary is also preserved in a manuscript dated 1721. Tentatively, then, one might surmise that the Upadeśasūtras were composed in South India in, perhaps, the seventeenth century. Other commentaries were written by Nīlakaṇṭha Regmī[111] in 1754 at Bhatgaon, Nepāla (Subodhinī); by Ākumalla Nṛsiṃha[112] in South India (Arthaprakāśikā); by Nṛsiṃha Kheḍakara,[113] probably in Mysore; by Parameśvara Yogīndra,[114] apparently in Tamilnadu (Jyotiṣānanda); by Premanidhi[115] (Kāśikā); by Malayavarman,[116] the ruler of Tākumaparvata (Kāśikā); by Lakṣmaṇa in South India (Jyotiḥpradīpikā); and by Veṅkaṭeśa in South India (Bhāvakaumudī).

It would not be possible to close this discussion of the literature on *jātaka* without reference to one of the most notorious texts of this genre, which has had numerous offshoots. This is the vast collection of thousands of potential

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by K. S. Nampūtirippāṭ, Kunnamkulam 1960; and with a Hindī *ṭīkā* by Gopeśa Kumāra Ojhā, Vārāṇasī 1971.

[106] CESS A 3, 71a—74a, and A 4.

[107] Published with Nīlakaṇṭha's *ṭīkā*, Kāśī 1874, Kāśī 1877, Calcutta 1884, Bombay 1888, and Allahabad 1888; with his own *ṭīkā* by Vināyaka Śāstrī Vetāla, Kāśī 1911; with a Marāṭhī translation by V. G. Navāthe, Jātakaśiromaṇi 1, 8, Bombay 1914; with the *ṭīkā* of Rāmayatna Ojhā, 2nd ed., Benares 1925; with the *ṭīkās* of Durgāprasāda Dviveda and Mādhava, Bombay 1925; with Nīlakaṇṭha's *ṭīkā* and a Bengālī translation by Rādhāvallabha Pāṭhaka, Calcutta 1926; with Sanskrit and Hindī *ṭīkās* by Acyutānanda Jhā as HSS 159, Benares 1943, 2nd ed. Benares 1952; with an English translation by B. Suryanarayana Rao, Bangalore 1932, rev. ed. by B. V. Raman, Bangalore 1944; with his own *ṭīkā* and an English translation of I—II by K. V. Abhyaṅkara, Ahmedabad 1951; with the Hindī *ṭīkā* of Kāśīrāma, Bombay 1958; and with the Sanskrit and Hindī *ṭīkās* of Sītārāma Jhā, 4th ed., Vārāṇasī 1970.

[108] Edited by Vindhyeśvarīprasāda Dvivedin, Benares 1879; with a Telugu *ṭīkā* by Veṅkaṭa Śāstrī, 2 vols., Rajahmundry-Gopalpur 1926; with the Hindī *ṭīkā* of Śrīnivāsa, 2nd ed. Ratlam 1929, 5th ed. Ratlam 1953; and with an English translation by V. Subrahmanya Sastri, Bangalore 1941, 2nd ed. Bangalore 1967.

[109] CESS A 4.

[110] CESS A 2, 61b—62a; A 3, 23b; and A 4.

[111] CESS A 3, 191b—192b, and A 4.

[112] CESS A 3, 195a.

[113] CESS A 3, 199b.

[114] CESS A 4.

[115] CESS A 4.

[116] CESS A 4.

horoscopes assembled under the name Bhṛgusaṃhitā, and presented in the form of a dialogue between Bhṛgu[117] and Śukra. The work contains thirteen gigantic *adhyāyas:* one for each zodiacal sign, and a Yogasāgara.[118] The earliest dated manuscript was copied in 1645; I doubt that the work antedates the sixteenth century. The manuscript copies all originate in North India, where some extraordinarily diligent fellow compiled it. A similar collection found in South India is the mammoth Saptarṣi nāḍi[119] in Tamil.

Tājika

The word *tājika* is derived from the Pahlavī Tāzīg, a term which the Iranians applied to the Arabs; it in turn is derived from the name of the Arab tribe, Ṭayyi'. Since the early eighth century, the Arabs and Persians who encroached on the Western coast of India were called Tājikas.[120] As the name for a branch of genethlialogy the term *tājika* refers to Indian adaptations of Arabic/Persian astrology, which was itself a combination of elements from Greek, Syriac, Sasanian, and Indian science.[121] In *tājika* texts not only are a number of astrological techniques and concepts foreign to *jātaka* found—including some like the ἀφέτης or *haylāj* (Sanskrit *hillāja*) that had been a part of the YJ but later forgotten in India—but also many technical terms—e.g., *kabūla (qabūl), antihā (intihā'), hadda (ḥadd), sahama (sahm)*, and many others.

The earliest author on *tājika* in Sanskrit was Samarasiṃha of the Prāgvāṭa-kula, who wrote his Gaṇakabhūṣaṇa or Tājikatantrasāra or Karmaprakā-śikā[122] in Gujarāt in 1274; his great-great-grandfather, Caṇḍasiṃha, had been a *saciva* of the Caulukya Mūlarāja II (ca. 1177–1179). Samarasiṃha names as his source the work of Khindika,[123] a name derived from the Arabic al-Hindī. There is a commentary, the Daivajñasantoṣiṇī or Karmaprakāśikāvṛtti, composed by Nārāyaṇa Sāmudrika[124] in about 1725.

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[117] CESS A 4.

[118] Published Bombay 1898 and 1937.

[119] Only the material relating to the first six signs seems to have been published: vol. 1, edited by K. Natesan as Madras GOS 82, Madras 1951; vol. 2, edited by S. Thangarel Nadar as Madras GOS 103, Madras 1953; vol. 3, edited by R. V. Rajagopala Aiyangar as Madras GOS 115, Madras 1954; vol. 4, edited by V. S. Seshadriyacharyar and C. G. Rajan as Madras GOS 123, Madras 1958; vol. 5, edited by R. V. Rajagopala Aiyangar and C. G. Rajan as Madras GOS 144, Madras 1956; and vol. 6, edited by C. G. Rajan and T. Chandrasekhar as Madras GOS 168, Madras 1961.

[120] D. Pingree, "Sanskrit Evidence for the Presence of Arabs, Jews, and Persians in Western India: *ca.* 700–1300", JOI Baroda.

[121] D. Pingree, "Astrology," in The Cambridge History of Arabic Literature.

[122] Edited with Nīlakaṇṭha's Tājikanīlakaṇṭhī, Meratha 1866.

[123] CESS A 2, 80a.

[124] CESS A 3, 166b–168a, and A 4.

A relatively short text on *tājika* in seventy-three verses is the Varṣaphala[125] attributed to Maṇittha,[126] whose name, which is that of the ancient Greek authority on *jātaka* (Μανέθων), was inspired by the Arabic technical term *muntahan*, which occurs in Sanskrit as *munthahā*. The earliest dated manuscript was copied in 1475. To a large extent based on the Varṣaphala is the Tājikamaṇi[127] completed in eighty-five verses by Mahīdhara at Vārāṇasī in 1585. Both these works are on the topic of anniversary horoscopes (*hāyana* or *varṣaphala*), which became a very prominent feature of *tājika*.

In about 1500 the well known Keśava of Nandigrāma wrote a Tājikapaddhati[128] on *hāyana* in twenty-six verses. Commentaries were written by Viśvanātha at Golagrāma in 1610 and by Mallāri[129] in 1612. A far fuller treatment of the subject is to be found in the Tājikasāra composed by Hari in 1523. A commentary on this was written by Sumatiharṣa Gaṇi at Khairābād in 1620. That Sūryadāsa who commented on Bhāskara's L and BG at Pārthapura in 1541 and 1538 respectively was also the author of a Tājikālaṅkāra. Perhaps in 1544 Govardhana[130] wrote a Tājikapadmakośa[131] on *hāyana*. Before 1559, the date at which the earliest manuscript was copied, Vāmana authored a Tājikasāroddhāra; while in about 1575 Nṛsiṃha, who was born at Nandigrāma in 1548, wrote a Varṣaphaladīpikā on *hāyana* and a Hillājadīpikā on the *haylāj*.

But the most noteworthy and popular book on *tājika* is the Tājikanīlakaṇṭhī[132] composed by Nīlakaṇṭha[133] at Kāśī in 1587. This is divided into two sections, which are often presented separately; the *saṃjñātantra* on general *tājika*, and the *varṣatantra* on *hāyana*. There exist commentaries composed by

[125] Poorly edited with a Hindī translation by Rāmaprasāda Bhaṭṭa Śarman, Solana 1943; I hope to publish soon a new edition based on Leipzig 1148; β 2 and P. 37 a in the Wellcome Institute for the History of Medicine; and IO 2529 C.

[126] CESS A 4.

[127] I have used Baroda 3145 and 9557.

[128] Published with Viśvanātha's *ṭīkā*, Kāśī 1869; and with a Telugu translation, Madras 1916.

[129] CESS A 4.

[130] CESS A 2, 134b—135b; A 3, 34a; and A 4.

[131] Published anonymously, [Benares 1877] and, with a Hindī translation, Lucknow 1905. Published as the work of Bhagavānadatta: with a Hindī translation, Bombay 1916; with Sītārāma Jhā's Hindī *ṭīkā*, Benares 1923; with Dīnānātha Jhā's Hindī *ṭīkā*, HSS 210, Benares 1951; and with a Hindī *ṭīkā* by Vāsudeva Gupta, Vārāṇasī [ND].

[132] Published [NP] 1851; with the *ṭīkā* of Viśvanātha, Bombay 1861 (only *saṃjñātantra*) and Benares 1865; Meraṭha 1866; Delhi 1868; with Viśvanātha's *ṭīkā*, Delhi 1871; Meerut 1875; with Govinda's *ṭīkā*, Delhi 1877 and Benares 1879; with Viśvanātha's *ṭīkā*, Bombay 1879; Bombay 1893; with the Hindī *ṭīkā* of Śaktidhara Śukula, Lucknow 1894; with Viśvanātha's *ṭīkā*, Bombay 1896 and Bombay 1900; with Viśvanātha's and Sītārāma Jhā's *ṭīkās*, Kāśī 1921, reprinted Benares 1930; with Viśvanātha's *ṭīkā*, Bombay 1923; with a *ṭīkā* by Sītārāma Jhā, MM 69, Benares 1936, 5th ed. Benares 1961; with the Sanskrit and Hindī *ṭīkās* of Gaṅgādhara Miśra, HSS 143, Benares 1941, reprinted Benares 1950; and with Viśvanātha's *ṭīkā* and a Hindi commentary by Vāsudeva Gupta, Vārāṇasī 1972.

[133] CESS A 3, 177b—189a, and A 4.

Nīlakaṇṭha's son Govinda,[134] who was born in 1569, at Kāśī in 1622 (Rasālā); by Viśvanātha at Kāśī in 1629; by Mādhava,[135] who was born in 1598 as the son of Nīlakaṇṭha's son Govinda, at Kāśī in 1633 (Śiśubodhinī); and by Harṣadhara (Śrīphalavardhinī).

Towards the end of the sixteenth century the high-ranking Mughul official 'Abd al-Raḥīm, who was born at Lahore in 1556 (his horoscope is given in Kṛṣṇa's *ṭīkā* on Śrīpati's JKP) as the son of Bairam Khān and who was given the title Khān-i Khānān (he is known as Nabbāba Khānakhānā[136] in Sanskrit), wrote a Kheṭakautuka[137] on *tājika* in 124 verses. At about the same time Gaṇeśa,[138] the son of Ḍhuṇḍhirāja who wrote the Jātakābharaṇa at Pārthapura in about 1525, composed a lengthy Tājikabhūṣaṇa[139] in fourteen *adhyāyas;* and Śaṅkara wrote a Tājikacandrikā or Samāphala at Nādur, in which he mentions the sixty-year cycle from 1567 to 1627 and of which the oldest dated manuscript was copied in 1607.

In the early seventeenth century Yādava Sūri, who belonged to a family dwelling at Prakāśa in Gujarāt, penned a Tājikayogasudhānidhi in sixteen *adhyāyas;* its date is apparently 1616. Soon afterwards his son, Bālakṛṣṇa,[140] composed a popular Tājikakaustubha in twelve *adhyāyas*, perhaps at Jambūsaras. Bālakṛṣṇa's contemporary was the Divākara whom we have mentioned several times before; he wrote a Varṣagaṇitabhūṣaṇa or Rathoddhatā and a commentary on it entitled Mañjubhāṣiṇī.

However, the *tājika* text best known to the scholarly world because of the studies of Weber[141] is the immensely valuable *nibandha*, the Hāyanaratna,[142] composed by Balabhadra for Shāh Shujā' at Rājamahala in 1629. Like the same author's Horāratna, it is a vast collection of excerpts from earlier writers' works. As well as most of the authorities that we have already mentioned Balabhadra cites from Tejaḥsiṃha and Padmanābha. The former is probably the Tejaḥsiṃha[143] who composed a Daivajñālaṅkṛti in Gujarāt in 1336, the latter the Padmanābha[144] who is the author of an Hillājāyurdāya, of which the oldest dated manuscript was copied in 1699.

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134 CESS A 2, 137b—141a; A 3, 35a; and A 4.

135 CESS A 4.

136 CESS A 2, 79b—80a; A 3, 26a; and A 4.

137 Published with a Hindī translation, Lucknow 1899 and Bombay 1901; with a Hindī *ṭīkā* by Sītārāma Jhā, Benares 1928, reprinted as MM 120, Benares [ND]; with a Hindī *ṭīkā* by Rāmateja Śāstrī, Benares 1929; with a Hindī *ṭīkā* by Dīnānātha Jhā, HSS 166, Benares 1944, 2nd ed. Benares 1956; and with an English translation and commentary in S. D. Udhrain, Star-lore, New Delhi 1973.

138 CESS A 2, 107a—110a; A 3, 28b; and A 4.

139 Published with a Marāṭhī translation by V. B. Thorāt, Poona 1911.

140 CESS A 4.

141 A. Weber, "Zur Geschichte der indischen Astrologie," IS 2 (1853), 236—287 and 412—418.

142 Published Kāśī 1867; Meraṭha 1875/76; and Bombay 1904.

143 CESS A 3, 89a.

144 CESS A 4.

Tājika continued to be discussed and described in the following centuries. Briefly, the literature includes: the Tājikaratna composed by Gaṅgādhara at Kāśī in 1653; the Tājikasāra written by Veṅkaṭeśa in 1654; the Tājikamañjarī composed by Jayadeva[145] at Śrīpura in 1671; the Tājikakalpalatā of Jayarāma,[146] of which the earliest dated manuscript was copied in 1711; the Tājikaratna written by Cirañjīva[147] of Navadvīpa, Bengal, probably in about 1725; the Tājikasārasudhānidhi composed by Nārāyaṇa Sāmudrika, the commentator on Samarasiṃha, in about 1725; and the Tājikālaṅkāra written by Śambhurāma at Dhavalapura in 1730.

[145] CESS A 3, 60b.
[146] CESS A 3, 61b.
[147] CESS A 3, 51b.

Chapter VI

CATARCHIC ASTROLOGY

To regard the time when the Moon conjoins with a particular *nakṣatra* as propitious or unpropitious for performing certain acts was an ancient custom in India.[1] We have, indeed, encountered systematic expositions of such systems already in the Śārdūlakarṇāvadāna (pp. 81—99). In the YJ (77—78) actions to be taken on the planetary week-days, when the Moon is in each of the zodiacal signs, in the years ruled by each of the planets, and various other *yogas* are described. The Gargasaṃhitā (*aṅga* 1) prescribes actions to be undertaken when the Moon is in each *nakṣatra* and in each *tithi* and *karaṇa;* see also the BS (97—99) and the Śārdūlakarṇāvadāna (pp. 201—203).

Eventually a separate science developed that used this notion of auspicious and inauspicious time-units, in combination with omens and astrological *yogas*, to establish the correct time for initiating various kinds of actions; this is the science of *muhūrta*, corresponding to Hellenistic catarchic astrology. In Indian treatises on catarchic astrology great importance is given to deciding the time for performing the *saṃskāras* and other ritual acts; this aspect of *muhūrta* strongly influenced *dharmaśāstra*, many treatises of which are entirely or partially devoted to this kind of prediction.[2] Also, a number of texts that will be discussed in this chapter represent conflations of *muhūrta* with omens, but with the *muhūrtas* as the more important component rather than the omens as in the GS and BS.

The earliest work that we know to have been devoted to *muhūrta* was the Ratnakośa composed by Lalla in, probably, the eighth century. Though a few fragmentary manuscripts of this work survive, and there are numerous quotations from it in later commentaries and *nibandhas*, its contents are not yet clear. However, Śrīpati, who wrote his Jyotiṣaratnamālā[3] at Rohiṇīkhaṇḍa in about 1050, claims to base a large part of it on the Ratnakośa. The contents of Śrīpati's work are: *saṃvatsara* (1) or the sixty-year cycle of Jupiter; the characteristics of *tithis* (2), week-days (3), *yogas* (4), *karaṇas* (5), *nakṣatras* (6), and *muhūrtas* (7); the *upagrahas* (8); the Sun's entry into the zodiacal signs

[1] See, for instance, the not always reliable account by P. V. Kane, History of Dharmaśāstra, vol. 5, part 1, Poona 1958, pp. 523—536.

[2] The *dharmaśāstra* texts on *muhūrta* will not be discussed here; information concerning them will be found in the appropriate entries in CESS.

[3] Published with Mahādeva's *ṭīkā*, Benares 1884, 2nd ed. Calcutta 1915; *adhyāyas* 1—6 were published by P. Poucha, "La Jyotiṣaratnamālā ou Guirlande des Joyaux d'Astrologie de Śrīpatibhaṭṭa," Arch. Or. 16 (1949), 277—309.

(*saṅkrānti;* 9); planetary transits (*gocara;* 10; cf. BS 103); the influence of the Moon (11) and of the ascendant (12); the *saṃskāras* (13); laying the sacred fire (14); the consecration of the king (15); military expeditions (*yātrā;* 16); marriage (*vivāha;* 17); building (*vāstu;* 18); entering the house (19); wearing clothes (20); and installing images of the gods (21). This became the standard arrangement for a pure *muhūrta* text; as usual, while the details of the interpretations of phenomena may vary, and while the methods employed tend to become increasingly elaborate, the basic structure of *muhūrta*, like those of the other sciences we have investigated in this volume, tended to remain unchanged. Śrīpati wrote his own Marāṭhī commentary on the JRM.[4] Of the Sanskrit commentaries the grandest is the *vivṛti* completed by Mahādeva, Āmarāja's nephew, in Gujarāt in 1264; it is especially valuable for its numerous citations of *jyotiṣa, dharma, purāṇa,* and other types of texts. Other commentaries were composed by Dāmodara[5] (Bālāvabodha); Paramakāruṇika[6] (Bālabodhinī in Gujarātī or Rājasthānī; the earliest dated manuscript was copied in 1636); and Vaijā Paṇḍita (the earliest dated manuscript was copied in 1493).

Contemporaneously with Śrīpati, Bhojarāja, the famous Paramāra ruler of Dhārā, wrote (or had written) the Rājamārtaṇḍa.[7] This text, naturally uninfluenced by the arrangement of Śrīpati's, deals, among other topics, with the names and qualities of the planets, *nakṣatras,* and zodiacal signs; with many *saṃskāras* in the order of their normal occurrences in life from conception till death; with military astrology; with building, installing images, digging wells, agriculture, planting trees, archery, mounting elephants, and a variety of other topics. Unfortunately, the printed edition includes material that does not belong to the original; for instance, it cites (p. 116) the opinion of the Kālamādhavīya, which was written by Mādhava in the late fourteenth century. A critical edition is a necessity before this fascinating collection of material on ordinary life in medieval India can be properly exploited.

In about 1100 Maheśvara,[8] the father of the great Bhāskara, wrote a brief but relatively popular Vṛttaśataka[9] on *muhūrta.*

Two of the Jaina scholars in the circle of Vastupāla, the minister of the Vāghelas Lavaṇaprasāda and Vīradhavala in Gujarāt from 1220 till 1240, wrote popular works on *muhūrta.* Udayaprabha Sūri[10] composed an Ārambhasiddhi or Pañcavimarśa[11] in 412 verses, on which Hemahaṃsa wrote a *vārttika* at Āśāpallī (Ahmadābād, Gujarāt?) in 1457 (Sudhīśṛṅgāra). And Naracandra

[4] Edited by M. G. Panse, Poona 1957.

[5] CESS A 3, 100a.

[6] CESS A 4.

[7] Published Bombay 1896; a selection of 286 verses (out of 1421 or 1462) on *tithis, vratas,* and *utsavas* was edited by P. V. Kane, "Passages from the Rājamārtaṇḍa on Tithis, Vratas and Utsavas," ABORI 36 (1956), 306—339.

[8] CESS A 4.

[9] I have used CS e. 147 (8) in the Bodleian Library, Oxford.

[10] CESS A 1, 57a—58a, and A 4.

[11] Published with Hemahaṃsa's *ṭīkā,* Bhavnagar [ND] and Bombay 1918.

Sūri[12] was the author of a Jyotiṣasāra or Nāracandra[13] in 4 *prakaraṇas*, on which a *ṭippaṇaka* was composed by Sāgaracandra Sūri before 1468, when the earliest dated manuscript was copied. Neither author, of course, deals with the proper moments for performing *saṃskāras*.

Perhaps at about the same time (some scholars claim that the date is about 1242, though the earliest dated manuscript was not copied till 1658), someone who claims to be Kālidāsa[14] and to have written at the court of Vikramāditya in 34 B.C. composed a Jyotirvidābharaṇa[15] on *muhūrta* with some omen material interspersed. Bhāvaratna[16] wrote his commentary, the Sukhabodhikā, at Pattana in 1711.

At Ālattūr in Kerala in the late thirteenth century Govindabhaṭṭa, one of the commentators on Varāhamihira's BJ, wrote a Muhūrtamaṇi, whose contents need to be investigated. A *vyākhyā* on this was composed by a fellow resident of Ālattūr (Aśvatthagrāma), the prolific Parameśvara, whose grandfather had been Govindabhaṭṭa's student, in the early fifteenth century.

At sometime before about 1365 someone wrote a Nāradasaṃhitā[17] ascribed to the sage Nārada;[18] for it is extensively quoted by Viṣṇuśarman in his Muhūrtadīpikā.[19] The NS, as do several other *muhūrta saṃhitās* (cf. GS 4—11) ascribed to *ṛṣis*, begins with planetary omens (2; *grahacāra*) similar to those in conventional omen *saṃhitās;* and appends to the usual *muhūrta* material (*adhyāyas* 3—31) other omen chapters: e.g., *sadyovṛṣṭi* (32; cf. BS 28), *kūrmavibhāga* (33; cf. GS 23), *utpāta* (34; cf. GS 39), and various topics (35; cf. GS 55—58; BS 31, 35—37). Viṣṇuśarman also knew a Vasiṣṭhasaṃhitā; this, however, is different from the Vasiṣṭhasaṃhitā[20] that is current now. This latter text, however, is at least as old as the fifteenth century; the earliest dated manuscript was copied in 1443, and the earliest quotations are by Śivarāja in his JN.[21] The contents of the VSA are very similar to those of the NS, save that much of the omen material in NS 32—37 is omitted. Another mixed text of this nature is the second GS already referred to in the chapter on omen literature.

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[12] CESS A 3, 132a—136a, and A 4.

[13] Published Surat 1913 and Bombay 1938.

[14] CESS A 2, 32b—34a, and A 4.

[15] Published with the *ṭīkā* of Bhāvaratna, Benares 1869; edited by Rasikamohana Caṭṭopādhyāya, Calcutta 1876; and edited with Bhāvaratna's *ṭīkā* by S. S. Jāmbhekara, Bombay 1908.

[16] CESS A 4.

[17] Published Vārāṇasī 1905; edited by Rasikamohana Caṭṭopādhyāya, 2nd ed., Calcutta 1915; with the Hindī *ṭīkā* of Vasatirāma Śarman, Bombay 1937, reprinted Bombay 1957.

[18] CESS A 3, 148a—149b, and A 4.

[19] E.g., NS 1, 4 on VM 1, 1; NS 1, 5 on VM 1, 2—4; and NS 1, 16 on VM 5, 36.

[20] Published Bombay 1915.

[21] E.g., VSA 37, 39 in JN, p. 191; VSA 37, 94—95 and 97 in JN, p. 196; VSA 37, 98—105 and 107—111 in JN, pp. 197—198; and VSA 37, 149 in JN, p. 199.

The most important authority on *muhūrta* in the fourteenth century, however, was Vidyāmādhava, who wrote his Muhūrtadarśana or Vidyāmādhavīya[22] in the Vijayanagara Empire in about 1360. Its fifteen *adhyāyas* are concerned with terminology and definitions (1; *saṃjñā*); faults (2; *doṣa*), exceptions (3; *apavāda*), and good qualities (4; *guṇa*) of *muhūrtas;* strengths and weaknesses (5; *balābala*); the *saṃskāras* (6–9); agriculture (10; *kṛṣibījavāpa*); installation of images of the gods (11; *devapratiṣṭhā*); military expeditions (12; *yātrā*); various other activities (13); on the *nakṣatras* (14); and on *gocara* (15). There is an extremely valuable *ṭīkā* on the VM, the Muhūrtadīpikā, written by Vidyāmādhava's son, Viṣṇuśarman, in about 1365; as has been noted several times above, this provides a rich store of citations from the antecedent literature on several branches of *jyotiḥśāstra.*

The other important source for quotations from earlier texts is the JN of Śivarāja. He does not, however, refer to the extraordinarily popular Bālabodha or Jyotiṣasārasaṅgraha of Muñjāditya.[23] But since the earliest dated manuscript of this latter work was copied in 1479, Muñjāditya must have flourished in about 1450 or perhaps a bit before. It is probably the elementary nature of the Bālabodha to which its popularity was due. A brief but also popular *muhūrta* poem is the Brahmavyavahāra or Trivikramaśataka[24] composed by Trivikrama[25] before 1484, when the earliest dated manuscript was copied. That manuscript also contains the commentary, Budhavallabha, of Gopīnātha.[26]

As in many other fields, so in *muhūrta* Keśava of Nandigrāma wrote an important work, the Muhūrtatattva.[27] His son, Gaṇeśa, dutifully wrote a *ṭīkā*, the Muhūrtadīpikā, at Nandigrāma before 1554. Another *ṭīkā* was written by Viśvanātha in the early seventeenth century; the oldest dated manuscript was copied in 1637. Probably also in the early sixteenth century Kāśīnātha[28] composed his very successful Śīghrabodha,[29] of which the earliest dated manu-

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[22] Edited with Viṣṇuśarman's *ṭīkā* by R. Shama Sastry as MSS 63, 67, and 70, Mysore 1923–1926.

[23] CESS A 4.

[24] I have used copies of 1651, 2617, and 5067 at the Viśveśvarānanda Vedic Research Institute.

[25] CESS A 3, 91b–92b, and A 4.

[26] CESS A 2, 132a–132b, and A 3, 33b.

[27] Published Benares 1856; and, with a Marāṭhī translation, by V. V. Jośī, 3rd ed., Poona 1927.

[28] CESS A 2, 39a–44a; A 3, 20a–20b; and A 4.

[29] Published Meerut [ND]; Bareilly 1851; Meerut 1852; [NP] 1853; Meerut 1854; Bombay 1858; Bombay 1863; Bombay 1864; Agra 1867; [Benares 1867]; Meerut 1868; Agra 1869; Bombay 1869; [Lucknow 1869]; Delhi 1874; with Caṇḍīdatta's Hindī *ṭīkā*, Lucknow 1874; [Delhi ?] 1876; Meerut 1877; [NP] 1877; Bombay 1878; Meerut [1878]; [NP] 1879; Bombay 1879; Meerut 1879; with the Brajbhāṣā *ṭīkā* of Hariprasāda Bhagīratha, Bombay 1881; [Delhi] 1886; Bombay 1903; Kāśī 1903; with Rāmeśvara Bhaṭṭa's Hindī *ṭīkā*, Agra 1906, 3rd ed. Agra 1922, 4th ed. Allahabad 1927; Lucknow 1911; Benares [1921], [1922], [1926], and [1928]; with Anūpamiśra's Hindī *ṭīkā* as HSS 51, Benares 1936; with Sītārāma Jhā's Hindī

script was copied in 1559. Probably also to be dated in the early sixteenth century is the brief Bālavivekinī or Pañcaviṃśatikā[30] of Nāhnidatta;[31] the earliest dated manuscript of it was copied in 1589.

A far more impressive treatise is the Muhūrtamārtaṇḍa[32] composed by Nārāyaṇa[33] at Ṭāpara north of Devagiri in 1571. A year later he wrote a

Table 6

MM	MC	MG
1. tyājya	1. śubhāśubha	1. saṃvatsarādi
2. nakṣatra	2. nakṣatra	2. tithi
3. saṃskāra	3. saṅkrānti	3. vāra
4. vivāha	4. gocara	4. nakṣatra
5. agnyādhāna	5. saṃskāra	5. yoga
6. gṛha	6. vivāha	6. karaṇa
7. yātrā	7. vadhūpraveśa	7. candratārābala
8. miśra	8. dvirāgamana	8. śubhāśubha
9. anadhyāya	9. agnyādhāna	9. tyājya
10. gocara	10. rājābhiṣeka	10. lagna
11. saṅkrānti	11. yātrā	11. muhūrta
	12. vāstu	12. saṅkrānti
	13. gṛhapraveśa	13. gocara
		14. saṃskāra
		15. vivāha
		16. agnyādhānarājyābhiṣeka
		17. yātrā
		18. vāstu
		19. gṛhapraveśa
		20. pratiṣṭhā
		21. miśra

ṭīkā as MM 25, Benares 1950; with CANDRAŚEKHARA PĀṬHAKA's Hindī *ṭīkā*, Benares 1966; and with KAILĀSAPATI MIŚRA's Hindī *ṭīkā*, Vārāṇasī [ND].

[30] Published Benares 1902; Darabhaṅgā 1910; with the Hindī *ṭīkā* of BACCŪ ŚARMAN, Darabhaṅgā [1911]; Darabhaṅgā [1924]; and edited by RĀMATEJA PĀṆḌEYA, Kāśī [ND].

[31] CESS A 3, 171b—172b, and A 4.

[32] Published [NP] 1836; Benares 1854; with Nārāyaṇa's *ṭīkā*, Bombay 1861, Poona 1865, Kāśī 1869, Madras 1871, Lucknow 1879, and Bombay 1894; with Nārāyaṇa's *ṭīkā* and the Marāṭhī translation of V. V. ŚĀSTRIN, Poona 1897, reprinted Bombay 1907, 2nd ed. [Bombay] 1917; with the Telugu *ṭīkā* of NORI GURULIṄGA ŚĀSTRĪ, Madras 1901; with Nārāyaṇa's *ṭīkā*, Bombay 1904; with the Gujarātī translation of GIRIJĀŚAṄKARA C. VYĀSA, Tintoi, Ahmadabad 1916; with the Gujarātī translation of SOMEŚVARA DVĀRAKĀDĀSA, Bombay 1921; with Nārāyaṇa's *ṭīkā* and RĀMATEJA PĀṆḌYA's Hindī commentary, Benares 1938; and with KAPILEŚVARA SĀSTRIN's Sanskrit and Hindī *ṭīkās* as KSS 145, Benares 1947.

[33] CESS A 3, 157b—163a, and A 4.

commentary, the Mārtaṇḍavallabha. A Laghumuhūrtamārtaṇḍa was apparently composed by Nārāyaṇa himself; an abridgment of the Muhūrtamārtaṇḍa was made by Nīlakaṇṭha[34] in 1680.

But within thirty years the pre-eminence of Nārāyaṇa's great treatise was eclipsed by Rāma, who completed the Muhūrtacintāmaṇi[35] with its *ṭīkā*, the Pramitākṣarā, at Kāśī in 1600. Another commentary, the Pīyūṣadhārā, was composed by Rāma's nephew, Govinda, at Kāśī in 1603. For the sake of comparison the titles of the *adhyāyas* in the works of Nārāyaṇa, Rāma, and Gaṇapati are presented in Table 6; this shows clearly Nārāyaṇa's new approach to the subject, Rāma's dependence on him, and Gaṇapati's return (anticipated by Viṭṭhala) to the old tradition of Śrīpati.

But before Gaṇapati wrote toward the end of the seventeenth century, a large number of lesser authors tried their hand. These include: Bhānu,[36] who wrote a Sajjanavallabha[37] at Māndhātṛ in Gujarāt (the earliest dated manuscript was copied in 1602); Nāgeśa, the author of the Grahaprabodha in 1619, who also composed a Muhūrtadīpaka; Viṭṭhala, the author of a Paddhatikalpavallī in 1626, who wrote a Muhūrtakalpadruma[38] at Kāśī in 1627; Raghuvīra, Viṭṭhala's son, who composed a Muhūrtasarvasva in 1635; Mahādeva,[39] the author of a brief Muhūrtadīpaka[40] at Añjāra in Kaccha in 1640 and of a *vyākhyā* on the same at Bhuja in 1661; Nandikeśvara,[41] who composed the Gaṇakamaṇḍana at Śrīsthala in Gujarāt in about 1640; Paramahaṃsa Parivrājakācārya,[42] who wrote a Muhūrtamuktāvalī,[43] of which the earliest dated manuscript was copied in 1645; Śrīkaṇṭha, who wrote another Muhūrtamuktā-

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[34] CESS A 3, 191b.

[35] Published with Rāma's *ṭīkā*, Benares 1848; Lahore 1853; Benares 1853; with Rāma's *ṭīkā*, Bombay 1859 and Lucknow 1869; with PRASANNAVADANA'S Hindī *ṭīkā*, Allahabad 1869; with Govinda's *ṭīkā*, Bombay 1872; with CAKRAPĀṆI PĀṬHAKA'S Hindī *ṭīkā*, Benares 1874; with Rāma's *ṭīkā*, Bombay 1880; with Govinda's *ṭīkā* [Bombay 1882]; with a Hindī *ṭīkā*, Calcutta 1896; with Govinda's *ṭīkā*, Bombay 1907; with NĪLAKAṆṬHA'S Hindī *ṭīkā*, Lucknow 1909, 3rd ed. [NP] 1915; with RAJANĪKĀNTA'S Bengālī version, Calcutta 1910; with a Kannaḍa *ṭīkā*, Bellary 1913; with MAHĀRĀJADĪNA DĪKṢITA'S Hindī *ṭīkā*, Benares 1914; with RISĀLADATTA MIŚRA'S Hindī *ṭīkā*, Benares 1916 and 1920; with MAHĪDHARA DHARMĀDHIKĀRĪ'S Hindī *ṭīkā*, Bombay 1919; with Govinda's and ANŪPA MIŚRA'S *ṭīkās*, Benares 1923; with Rāma's *ṭīkā*, Benares 1925; with a Hindī *ṭīkā*, Benares [1926]; with Govinda's *ṭīkā*, Bombay 1933; with Govinda's *ṭīkā*, 5th ed., Bombay 1945; with KAPILEŚVARA ŚĀSTRĪ'S Hindī *ṭīkā* as HSS 135, Benares 1948; with Govinda's *ṭīkā*, 2nd ed., Benares 1954; and with SĪTĀRĀMA JHĀ'S Hindī *ṭīkā*, Vārāṇasī 1969.

[36] CESS A 4.

[37] Published in Grantharatnamālā 5, 1892.

[38] Edited by KṚṢṆAŚAṄKARA KEŚAVARĀMA, Bombay 1935.

[39] CESS A 4.

[40] Published with his own *vyākhyā*, Kāśī 1867; Bombay 1877; and Bombay 1915.

[41] CESS A 3, 131a—131b, and A 4.

[42] CESS A 4.

[43] Published Benares 1875 and 1876.

valī, whose earliest dated manuscript was copied in 1656, for Vāḍavāna at Nāḍāpagrāma; Raghunātha Kaṇṭhīrava, who composed the Muhūrtamālā at Kāśī in 1660; and Yadunandana, the author of a Muhūrtamañjarī in 1669. Clearly, the interest in *muhūrta* during the seventeenth century was concentrated in Benares and Gujarāt. This did not change when Gaṇapati Rāvala[44] completed his gigantic Muhūrtagaṇapati[45] at Kāśī in 1686.

In the eighteenth century the only notable treatises on *muhūrta* were the Ratnadyota[46] composed by Gaṅgārāma Dviveda[47] in 1718 and the Jyotiścandrārka[48] composed by Rudradeva Śarman at Kāśī in 1726. But the last such work to which reference should be made here is the Vyavahāraratna[49] written by Bhānunātha[50] in Mithilā in 1872. This tradition, like that of genethlialogy, is still very much alive.

Yātrā

Military "astrology," an aspect of catarchic astrology in which the Indian developments influenced the Syriac scholar, Theophilus of Edessa,[51] in the eighth century and through him the later astrology of Islam, Byzantium, and Western Europe, began in India with the omens during the late first millennium B.C. It is found, then, in such texts as the GS (32–34) and in numerous other collections of omens, including the Narapatijayacaryā and other texts on *svara*, and regularly in treatises on *muhūrta*. *Yātrā*, which combines omens with real astrology, is also the subject of a section of the YJ (73–76); in the commentary thereon (vol. 2, pp. 389–393) a partial list of authorities on the subject, numbering fifty-six, was given. But here only the independent literature on the subject will be briefly considered.

The earliest separate treatises on *yātrā* that we have are the three composed by Varāhamihira in the sixth century: the Ṭikanikayātrā,[52] the Yogayātrā,[53]

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[44] CESS A 2, 89b–92a; A 3, 27a–27b; and A 4.

[45] Published Bombay 1859 and 1863; Kāśī 1864; Lucknow 1875; Bombay 1887; with Sūryanārāyaṇa Siddhāntī's Hindī translation, Lucknow 1894; Bombay 1897; with Rāmasvarūpa Śarman's Hindī *ṭīkā*, Bombay 1898, reprinted Bombay 1910 and Bombay 1954.

[46] Published with a Hindī version, 2nd ed., Lucknow 1899; and with Bhagavadatta Śāstrī's Hindī *ṭīkā*, Ayodhyā [ND].

[47] CESS A 2, 86b–87a; A 3, 27a; and A 4.

[48] The first five of the eight chapters with Rudradeva's own *ṭīkā*, the Kāśikā, were edited by Khūbacanda Śarman, Lucknow 1927.

[49] Published with Sītārāma Jhā's Hindī *ṭīkā* as MM 224, Benares 1952.

[50] CESS A 4.

[51] D. Pingree in Viator 7 (1976), 148–149.

[52] Edited by V. K. Pandit, "Ṭikanikayātrā of Varāhamihira," JUB 20 (Arts 2&) (1951), 40–63.

[53] *Adhyāyas* 1–9 with a German translation were edited by H. Kern, "Die Yogayātrā des Varāhamihira," IS 10 (1868), 161–212; 14 (1876), 312–358; and 15

and the Bṛhadyātrā.[54] Verses from each of these works occur in the other two. In addition to the omens and astrology proper, the BY (18), following the lead of Sphujidhvaja (YJ 76, 66 and 77, 1), gives detailed instructions for the worship of the planets *(grahayajña)*. Commentaries on the YY and the BY were composed by Bhaṭṭotpala in Kāśmīra in about 970, and on the BY by Sūryadeva at Gaṅgāpura in the early thirteenth century; of the two commentaries on the BY all that now survives seems to be a miserable fragment of Bhaṭṭotpala's. Varāhamihira refers to Bādarāyaṇa[55] as one of his authorities, and Bhaṭṭotpala in his *ṭīkā* on the YY cites many verses from a Bādarāyaṇīyayātrā, of which a few manuscript copies are known.[56]

After the tenth century, new literature on military astrology (aside from *adhyāyas* in *muhūrta* texts) seems to have followed the models of the Narapatijayacaryā and the Samarasāra rather than Varāhamihira; such seems to be the case, for example, with the Yuddhajayotsava of Gaṅgārāma,[57] and it is also to a large extent true of Kumāra Gaṇaka,[58] who wrote his Raṇadīpikā[59] in Kerala. As yet little is known of the Rājavijaya of Raṇahastin save that it was composed for a king named Mandana, the son of Hammīra, the son of Siṃhanadeva, and that the oldest dated manuscript was copied in 1600. Clearly Mandana is the Haihaya (Kalacuri) ruler of Ratnapura, Madanabrahman, the son of Ḍaṃghīra (?), the son of Siṅghaṇa, who is mentioned in the first Kosgain (Kosaṅga) Stone Inscription of his (Madanabrahman's) great-grandson Vāharendra,[60] who ruled from about 1480 till about 1515. Raṇahastin, therefore, flourished at Ratanpur north of Bilāspur in Madhya Pradeśa in about 1400.

Vivāha

Varāhamihira incorporated into his BS (102) a chapter on the astrology of marriage entitled *vivāhapaṭala*, the "marriage chest;" this was attributed to Vindhyavāsin by his commentator, Bhaṭṭotpala. But he also wrote a separate and more extensive treatise on the astrology of marriage, also entitled Vivāhapaṭala.[61] A commentary on this was written by the faithful Bhaṭṭotpala at

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(1878), 167—184, reprinted in his Verspreide Geschriften, vol. 1, 's-Gravenhage 1913, pp. 97—168; complete edition by JAGDISH LAL, Lahore 1944.

[54] Edited with a fragment of Bhaṭṭotpala's commentary by D. PINGREE, Madras 1972.

[55] CESS A4.

[56] I have used PM 1313 in the Adyar Library and G 6412 in the Asiatic Society of Bengal.

[57] CESS A2, 86a—86b.

[58] CESS A2, 46b, and A4.

[59] Edited K. SĀMBAŚIVA ŚĀSTRĪ as TSS 95, Trivandrum 1928.

[60] CII IV, Ootacamund 1955, pp. 557—563.

[61] I have used manuscript 9316 of the Oriental Institute in Baroda, which also contains Bhaṭṭotpala's commentary.

Kāśmīra in about 970. Thereafter, when *muhūrta* treatises became popular, they all included a section on *vivāha*—sometimes little else; and, of course, most works on *jātaka* also included discussions of this topic. Thus, Viṣṇuśarman, in commenting on VM 8 in about 1365, quotes not only from Varāhamihira, but also from Atri, Kalyāṇavarman, Gārgya, Guru, Narapati, Nārada, Bṛhaspati, Bharadvāja, Bhāgila, Bhṛgu, Yavaneśvara (not Sphujidhvaja or Mīnarāja), Lalla, Vasiṣṭha, Vāmadeva, Vāmana, Śaunaka, Śrīpati, and the Saptarṣis.

He quotes as well from a number of works whose titles but not authors he names. Among these is the Vivāhavṛndāvana,[62] which is indeed the work of that title[63] composed by Keśavārka.[64] In seventeen *adhyāyas* it deals in unparalleled completeness with all aspects of the subject. A commentary, the Vivāhadīpikā or Karapīḍanadīpikā, was composed by Gaṇeśa at Nandigrāma in 1554. Also ascribed to a Keśavārka[65] is a Mauñjīpaṭala[66] in but twelve verses.

The other *vivāha* texts that we have include the Sārasamuccaya or Vivāhapaṭala[67] of Sāraṅgapāṇi, a *nibandha* based largely on the Sārasamuccaya of Vaidyanātha (the earliest dated manuscript was copied in 1597); the Vivāhapaṭala[68] of Brahmāditya[69] (the earliest dated manuscript was copied in 1605); and the Vivāhapaṭala[70] composed by Pītāmbara[71] at Stambhatīrtha (Cambay, Gujarāt) (the earliest dated manuscript was copied in 1615).

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[62] Vivāhavṛndāvana 3, 3—4 are quoted on VM 8, 18, and Vivāhavṛndāvana 3, 10 on VM 8, 20.

[63] Published with Gaṇeśa's *ṭīkā*, Kāśī 1868; with KĀŚĪRĀMA's Hindī *ṭīkā*, Bombay 1907; with ŚIVADATTA TRIPĀṬHIN's Hindī *ṭīkā*, Kāśī 1909; and with Gaṇeśa's *ṭīkā*, Bombay 1909.

[64] CESS A 2, 75a—77a; A 3, 25a; and A 4.

[65] CESS A 2, 75a, and A 4.

[66] Edited by K. K. RAIKVA, Vivāhapaṭalam, Bombay 1935, pp. 63—65.

[67] Edited RAIKVA, ibid., pp. 1—62.

[68] I have used the fragmentary Harvard 405, which contains a commentary attributed to Sumatiharṣa.

[69] CESS A 4.

[70] Edited RAIKVA, ibid. pp. 66—79.

[71] CESS A 4.

Chapter VII

INTERROGATIONS

In catarchic astrology the *jyotiṣī* determines for his client the moment *(muhūrta)* at which it is most propitious for him to undertake a specific act; in interrogations *(praśna)* he responds to a query about some aspect of the client's life on the basis of the horoscope of the moment of the query. Obviously, there is considerable overlapping of topics and methods between these two branches of astrology. *Praśna* is also related to omens since the latter are of two kinds: spontaneous and induced. The second variety, in which the diviner requests that the gods send him an omen, has clear similarities to *praśna*. Even the ceremonies of ritual purification and supplication used for induced omens (see, e.g., BS 24 and 43) are reflected in *praśna* texts (e.g., PJ 3–4). But in general the techniques of *praśna* are derived from *jātaka*.

And it is in a *jātaka* treatise, Sphujidhvaja's YJ, that *praśna* was introduced to India from the Hellenistic world. Sphujidhvaja begins (YJ 52, 1–5) with rules for reconstructing the lost horoscope of the nativity of the client from the horoscope of the time of his query; this topic, entitled *naṣṭajātaka*, was normally dealt with in later *jātaka* texts. Thereafter he discusses methods of determining the subject of the querist's question before he puts it (YJ 52, 7–10, and 53–62); in part he uses the pharmacological categories of *āyurveda* (YJ 62) associated with celestial bodies. The following *adhyāya* (YJ 63) answers the question of whether what the querist is thinking of will in fact occur; and then there come discussions of lost or stolen objects (YJ 64), of sickness and death (YJ 65), of the sex of unborn or unseen children (YJ 66), of dinner (YJ 67), of various aspects of sleep (YJ 68), and of the subjects of dreams (YJ 69–70). The final two *adhyāyas* in this section (YJ 71–72) give elaborate rules for reconstructing names from astrological phenomena.

Only parts of this treatment of *praśna* are found in the Ṣaṭpañcāśikā[1]

[1] Published with Nandakumāra's Bengālī translation, Calcutta 1824; with Bhaṭṭotpala's *ṭīkā*, [Calcutta 1834?] and [Calcutta ?] 1834; with Badrīlāla's Hindī *ṭīkā*, Benares 1847; with Bhaṭṭotpala's *ṭīkā*, Benares [ca. 1851], and Bombay 1858, 1864, and 1866; with Badrīlāla's Hindī *ṭīkā*, [Agra] 1868 and 1871; Bangalore 1872; with Bhaṭṭotpala's *ṭīkā* [NP] 1873 with Badrīlāla's Hindī *ṭīkā*, Lahore 1874 and Meerut 1874; with Bhaṭṭotpala's *ṭīkā*, Bombay 1875; with Badrīnātha's Hindī *ṭīkā*, Lucknow 1876; with Bhaṭṭotpala's *ṭīkā*, Calcutta 1876; with Kṛṣṇa's *ṭīkā*, Bahrampore 1877; with Bhaṭṭotpala's *ṭīkā*, Bombay 1881; with the English translation of N. C. Iyer, [Madras?] 1887; with Veragama Puñchi-Baṇḍāra's Siṃhala *ṭīkā*, [Colombo] 1888; with Bhaṭṭotpala's *ṭīkā*, Bombay 1888 and Dharvad 1895; with Badrīnātha's Hindī *ṭīkā*, Lucknow 1901; with N. P. Nākhare's

composed by Varāhamihira's son, Pṛthuyaśas,[2] in the second half of the sixth century. He is interested in travel, warfare, profit and loss, sickness and death, marriage, and pregnancy. The most important commentaries on these fifty-six verses were composed by Bhaṭṭotpala in Kāśmīra in about 970, by Parameśvara in Kerala in the early fifteenth century, and by Dāmodara Rāṇabha[3] at Kāśī in about 1680 (Prakāśikā). Similar in content and in brevity are Bādarāyaṇa's[4] Praśnavidyā[5] in seventy-six verses, on which Bhaṭṭotpala wrote a commentary in about 970, and Bhaṭṭotpala's own Praśnajñāna or Āryāsaptati[6] in seventy verses, on which commentaries were composed by Rāmakṛṣṇa at Amarāvatī and by Śrīdatta.

The amount of detail in *praśna* texts, though not their scope, was enlarged in the Vidvajjanavallabha[7] written by (or for) the Paramāra Bhojarāja of Dhārā in the first half of the eleventh century. This poem contains 180 verses divided into eighteen *adhyāyas;* nine verses are taken from Bādarāyaṇa.[8] At about the same time, if the ascription to Śrīpati of Rohiṇīkhaṇḍa is valid (the work is also, more obviously falsely, associated with Varāhamihira in 15, 43), there was composed a Daivajñavallabha[9] in 250 verses divided into fifteen *adhyāyas,* of which the last is almost entirely derived from Varāhamihira's *yātrā* works.[10]

The only rival to Pṛthuyaśas' Ṣaṭpañcāśikā for popularity among *praśna* treatises is the Bhuvanadīpaka[11] that Padmaprabha Sūri,[12] a member of the

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Marāṭhī *ṭīkā*, Belgaum 1911; with Bhaṭṭotpala's *ṭīkā* and A. M. Vāgholīkar's Marāṭhī translation, Bombay 1911; with Bhaṭṭotpala's *ṭīkā* and Sītārāma Jhā's Hindī *ṭīkā*, Benares 1924; with V. Subrahmanya Sastri's English translation, Bangalore 1941, 2nd ed. Bangalore 1966; and with Bhaṭṭotpala's *ṭīkā* and Dīnānātha Jhā's *ṭīkā* as HSS 149, Benares 1947.

[2] CESS A 4.

[3] CESS A 3, 101a—102a, and A 4.

[4] CESS A 4.

[5] Edited with Bhaṭṭotpala's *ṭīkā* by J. S. Pade, Baroda 1972.

[6] Published with Mukundarāma's *ṭīkā*, 2nd ed., Bombay 1930; with the English translation of V. Subrahmanya Sastri and M. R. Bhat, Bangalore 1949, 2nd ed. Bangalore 1971; and with Vāsudeva Gupta's Hindī *ṭīkā*, Kāśī 1957.

[7] Edited by D. Pingree, Baroda 1970.

[8] These are:

VV	PV	VV	PV
3, 7	42	14, 5—6	40—41
10, 6	30	17, 16—21	24—28

[9] Published with Nārāyaṇa's Hindī *ṭīkā*, Bombay 1937.

[10] 1—2 = YY 4, 1—2; 3—10 = TY 7, 1—8; 12—21 = BY 9, 8—17; 23 = BY 9, 18; 24 = BY 2, 13; 25 = ṬY 1, 7; 26—27 = BY 8, 13—14; 28 = BY 8, 19; 29 = ṬY 5, 5; and 30—31 = BY 9, 3—4.

[11] Edited with Nārāyaṇa Bhaṭṭa's *ṭīkā* by Rasikamohana Caṭṭopādhyāya, Calcutta 1884; with D. D. N. Silva's Siṃhala translation, [Colombo] 1888; with a *ṭīkā*, Bombay 1888; with Baccū Śarman Jhā's Sanskrit and Hindī *ṭīkās*, Bombay 1914, reprinted Bombay 1953; and with Śukadeva Caturvedin's Hindī *bhāṣya*, Delhi 1976.

[12] CESS A 4.

Nāgapurīya Tapā Gaccha of Jainas, wrote in 1164. It gives the elements of astrology (1–42); lists the queries to be judged from each astrological place (42–54), and discusses, in addition to more common topics, prices (127–137), sailing (138–144), and sex (163–164). There are several commentaries; the most notable is that written by the Jaina Siṃhatilaka Sūri at Vijāpura in 1269. Contemporary with Padmaprabha was another Jaina, Naracandropādhyāya of the Kāśahrada Gaccha who composed the Beḍāvṛtti on his own Janmasamudra in Gujarāt in 1167. A decade later, in 1177, he wrote a Praśnaśata with accompanying *avacūrṇi;* he also is the author of the succinct Jñānacaturviṃśikā.[13] A few years after this Caṇḍeśvara, who is probably identical with the scholar who commented on the SS in Mithilā in about 1185, produced an enormous Praśnavidyā in thirty-five or forty *adhyāyas.* Unfortunately I have as yet had access only to incomplete manuscripts of this work,[14] but from these the extreme importance of this treatise for a history of *praśna* in India is evident.

Hemaprabha Sūri, the pupil of Devendra Sūri, is generally alleged to have written the Trailokyaprakāśa[15] in 1248; in any case, the earliest dated manuscript was copied in 1457. This invaluable treatise is a Sanskrit version of an Arabic (or Persian) work on interrogations (it is filled with *tājika* technical terms not recognized as such by the editor) arranged in the standard fashion of Arabic astrology—a fashion going back to Theophilus of Edessa—that is, by the queries appropriate to each astrological place.

At sometime before 1569 (if that date for the copying of a manuscript of the work is correct; the next was copied in 1647) someone published a Lokamanoramā[16] in twenty-two verses under the name of Garga;[17] this gives a computation that determines substances in the three categories of animal, vegetable, and mineral, and some of their attributes.

In the early sixteenth century—he was a leader of the Gosvāmins (of the followers of Caitanya ?), and the earliest dated manuscript of his work was copied in 1543—Nārāyaṇadāsa Siddha[18] composed the Praśnavaiṣṇava or Praśnārṇavaplava[19] in which again elements of *tājika* (i.e., Arabic-Persian) interrogational astrology enter into *praśna.* Also in the early sixteenth century Kāśīnātha[20] composed his Praśnapradīpa;[21] the earliest dated manuscript was

[13] Edited A. Śarman, Hyderabad 1956.

[14] 1835 and 1881 in the University of Pennsylvania.

[15] Edited with a Hindī version by R. S. Sharma, New Delhi 1967.

[16] Published with a *ṭīkā*, Benares 1899; with Baccū Śarman Jhā's Hindī *ṭīkā*, Bombay 1909, reprinted Bombay 1938; and with V. Timmaṇa Śāstri's Telugu translation, Bellari 1917.

[17] CESS A 2, 120b—122b; A 3, 30a—30b; and A 4.

[18] CESS A 3, 168b—171a, and A 4.

[19] Published Kāśī 1869; edited by Nārāyaṇa Śāstrin as CSS 2, Kāśī 1896; with Budhavasati Rāma's Hindī *ṭīkā*, Bombay 1912; and with G. Ś. Deśiṃgakara's Marāṭhī translation, Belgaum 1925.

[20] CESS A 2, 35b—36b; A 3, 19b; and A 4.

[21] Published Vārāṇasī 1866.

copied in 1556. And perhaps from the same period is the Praśnamāṇikyamālā of Paramānanda Śarman;[22] one manuscript is said to have been copied in 1560, but the author is also said to have flourished at the court of Balavantasiṃha, the Mahārāja of Kāśī in about 1748.

But we return to a secure chronology and to the renewed influence to *tājika* science with the Praśnatantra[23] written by that Nīlakaṇṭha who composed the Tājikanīlakaṇṭhī in 1587. In the course of this treatise he quotes many verses from earlier works, making it a sort of *nibandha;* his favorite authorities besides the Tājikas, are Pṛthuyaśas and Padmaprabha Sūri.

In the seventeenth century *praśna* was the subject of a number of treatises, many of which cannot be securely dated. Among these are to be included the Praśnajñāna of Brahmārka,[24] of which the earliest dated manuscript was copied in 1622, and the Jñānamañjarī of Ṛṣiśarman,[25] of which the earliest dated manuscript was copied in 1646. Probably to be included in this group is the Praśnatattva[26] of Cakrapāṇi,[27] whose floruit lies between 1514, the year in which Vibhākara composed his Praśnakaumudī which Cakrapāṇi cites (10, 18), and 1800, the year in which the earliest dated manuscript of the Praśnatattva was copied. Other texts on *praśna* written in the seventeenth century include: the Praśnabhairava[28] composed by Gaṅgādhara, the author also of works on *jātaka*, *koṣṭhaka*, *muhūrta*, and *tājika*, at Kāśī in 1629; the Praśnapradīpa written by Mahādeva, the author of the Muhūrtadīpaka, in Kaccha in 1647; the Praśnamārga[29] composed by Nātha,[30] a member of the Panakkāṭṭu[31] family of Iṭakkāṭ in Kerala, in 1650 (the author wrote his own *ṭīkā* on this, the Durgamārthaprakāśinī); and the Praśnaśiromaṇi[32] composed by that Rudramaṇi Tripāṭhin who wrote the Ramalenduprakāśa in 1682.

As in the cases of the other astrological sciences in India, interest in *praśna* has continued into modern times. Here it is necessary only to mention the Praśnasāra written by Govinda[33] at Devagiri, probably in the second quarter

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[22] CESS A 4.

[23] Often published with the Tājikanīlakaṇṭhī. It was also translated into English by G. Sri Rama Murthi, Hindu Horary Astrology, Tekkali 1960, and by B. V. Raman, Bangalore 1970.

[24] CESS A 4.

[25] CESS A 1, 59a—59b; A 2, 17b; and A 4.

[26] I have used University of Pennsylvania 698.

[27] CESS A 3, 38a—38b.

[28] Published with a Marāṭhī version, Poona 1868, reprinted Poona 1875 and 1881.

[29] *Adhyāyas* 1—16 (out of 32) edited by Punnaśśeri Nampi Nīlakaṇṭha Śarman, Kalpathi-Palghat 1926; and *adhyāyas* 1—12 published with an English translation and the Hindī *ṭīkā* of Śukadeva Caturvedī, Delhi 1978.

[30] CESS A 3, 147a.

[31] CESS A 4.

[32] Published with the Hindī *ṭīkā* of Rāmadayālu, Bombay 1951, reprinted Bombay 1962.

[33] CESS A 2, 141a—141b, and A 4.

of the eighteenth century; the Praśnaratna[34] composed by Nandarāma Miśra[35] at Kāmyakavana in Rājasthān in 1767 (the author completed his *ṭippaṇī* on this in 1770); the Praśnacaṇḍeśvara[36] of Rāmakṛṣṇa; and, finally, the Praśnāyana[37] composed by Puruṣottama Mūssatu[38] at Siprādeśa in Kerala in 1881 (the author wrote his own *vyākhyā* on this).

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[34] Published with SUNDARALĀLA ŚARMAN's Hindī *ṭīkā*, Bombay 1923, reprinted Bombay 1953.

[35] CESS A 3, 128b—130b, and A 4.

[36] Published with VIṢṆUDATTA VAIDIKA's Sanskrit and Hindī *ṭīkās*, Bombay 1955, reprinted Bombay 1960.

[37] Edited with Puruṣottama's *vyākhyā* by K. RAGHAVAN PILLAI as TSS 223, Trivandrum 1968.

[38] CESS A 4.

Chapter VIII

ENCYCLOPAEDIAS AND DICTIONARIES

Some early authors on *jyotiṣa*, such as Varāhamihira, Lalla, Śrīpati, and Bhojarāja, wrote works on several of this *śāstra's* branches. In this chapter I wish to consider those who attempted to encompass the same diversity within one work.

The earliest of such authors is a Buddhist Mahāsthavira from Śrīlaṅkā, Anavamadarśin Saṅgharāja[1] of the Hastavanagalya Mahāvihāra, who wrote his Daivajñakāmadhenu[2] during the reign of Parākramabāhu II (1236–1271), apparently in 1241. This deals with omens, *jātaka*, *muhūrta*, and *praśna*. Anavamadarśin's sources include Varāhamihira and Bhojarāja.

In 1315 the Jaina scholar Ṭhakkura Pherū[3] composed in Prakrit at Kannāṇapura a Jyotiṣasāra[4] on astronomy, *jātaka*, and *muhūrta*. To this is added a separate work on mathematics, the Gaṇitasāra,[5] also in Prakrit.

The next work that ought to be placed in this category combines *jātaka* with *muhūrta;* it is Śrīnivāsa's Śuddhidīpikā.[6] His date is a matter of great uncertainty, but he probably flourished in the fourteenth or fifteenth century. The earliest dated manuscript was copied in 1607; but a commentary, the Arthakaumudī, had been penned by Govindānanda Kavikaṅkaṇa[7] nearly a century before. The Śuddhidīpikā was popular primarily in Bengal and Mithilā, so that this Śrīnivāsa probably lived in that area of India.

Śūramahāṭha Śivadāsa, (or Śivarāja), however, the author of the largest extant astrological *nibandha*, the Jyotirnibandha,[8] probably lived in Mahārāṣṭra or Madhya Pradeśa. Though the edited text contains various additions from

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[1] CESS A 1, 42b–43a, and A 3, 13a.

[2] Edited by Śīlaskandha as BSS 25, Benares 1906.

[3] CESS A 3, 78a–78b, and A 4.

[4] Edited by Agaracanda and B. Nāhaṭā, Ratnaparīkṣādisaptagranthasaṅgraha, as RPG 44, Jodhpur 1961, pt. 2, pp. 1–40.

[5] Ibid., pt. 2, pp. 41–74.

[6] Edited with Govindānanda's *ṭīkā* and a Bengālī translation, Calcutta 1883, 2nd ed. Calcutta 1901; with the same *ṭīkā*, Calcutta 1901 and Calcutta 1927; with Kanhaiyālāla Miśra's Hindī *ṭīkā*, Bombay 1906, reprinted Bombay 1936; and with an Oriyā translation, Cuttack 1964.

[7] CESS A 2, 144a–144b, and A 3, 35b.

[8] Published Benares, 1878, and edited by Raṅganātha Vaidya as ASS 85, Poona 1919.

the seventeenth century[9] (its relation to the revision by Kṛṣṇa,[10] the Saṃhitāsāra, has not been investigated), the earliest dated manuscript was copied in 1579 and the JN was cited by Pītāmbara and others earlier in the sixteenth century. Moreover, Śivadāsa (p. 25) mentions 1440 as the first year of a sixty-year cycle, which it was in the Northern Cycle. One must conclude, therefore, that he wrote in the latter half of the fifteenth century. His work is an extraordinarily rich collection of excerpts on all branches of astrology and some branches of divination from a wide range of named sources, many of which are no longer extant. A thorough investigation of Śivadāsa's manuscripts and his sources would do much to illuminate the rather obscure history of Indian astrology outside of Gujarāt in the thirteenth and fourteenth centuries.

The most extensive encyclopaedia of science conceived and executed in premodern India was the Ṭoḍarānanda[11] in twenty-three *saukhyas* sponsored by Ṭoḍaramalla,[12] an official in Akbar's government from at least 1565 till his death in 1589. He entrusted the Jyautiṣasaukhya, the third section, along with several sections on branches of *dharmaśāstra* to Nīlakaṇṭha, who later wrote the far more influential Tājikanīlakaṇṭhī and Praśnakaumudī. Nīlakaṇṭha completed the Jyautiṣasaukhya in 1572; it contains three *skandhas*—on *saṃhitā* (omens), on *gaṇita* (astronomy; it is not known whether or not mathematics was included), and on *horā* (genethlialogy). There are also two *saukhyas* by Nīlakaṇṭha on *muhūrta*, one of which does not appear as part of Ṭoḍaramalla's plan as reconstructed; these are the Vivāhasaukhya and the Vāstusaukhya, which latter is *saukhya* 5. Judging from the quality of Nīlakaṇṭha's published works these encyclopedic opera would be well worth investigating.

On a smaller scale Kṛpāśaṅkara[13] composed a Jyotiṣkedāra[14] in 1627. This work has four *āvalis: saṃhitā* (including *muhūrta*) *gaṇita* (astronomy only), *horā* (*jātaka* and *tājika*), and *praśna*. There is a commentary by Cirañjīva Bhaṭṭa,[15] who wrote a Rāmaprakāśa at Indurakhī, Gwalior, in 1647.

At about the same time Śuka composed a Jyotiṣasāra[16] that is primarily on *muhūrta*, but includes a substantial amount of *jātaka* and *praśna* material. The earliest dated manuscript was copied in 1647. It was probably in the eighteenth century that someone claiming to be the great poet, Kālidāsa,[17] wrote an

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[9] S. L. Katre, "Śivadāsa's Jyotirnibandha: the Work and its Date," NIA 5 (1942–43), 275–279.

[10] CESS A 2, 52b.

[11] The first two *saukhyas*, entitled Sargasaukhya and Avatārasaukhya, were edited by P. L. Vaidya, Ganga OS 5, Bikaner 1948.

[12] CESS A 3, 77b–78a, and A 4.

[13] CESS A 2, 49b–50a.

[14] I have used an incomplete manuscript, 1869 in the University of Pennsylvania.

[15] CESS A 3, 51a–51b.

[16] Published with a Hindī *ṭīkā*, Bombay 1956.

[17] CESS A 2, 34b, and A 3, 19b.

Uttarakālāmṛta[18] in South India as a supplement to Veṅkaṭa Yajvan's popular Kālāmṛta. Ps.-Kālidāsa's work concerns *jātaka* and *muhūrta*.

Kośa

Though various normal Sanskrit dictionaries contain definitions of terms used in astronomy and astrology (e.g., a large part of the first *khaṇḍa* of Amarasiṃha's Liṅgānuśāsana), very few specialized dictionaries of such terms were produced. It appears that the only one describing the traditional Sanskrit vocabulary is Haridatta's Gaṇitanāmamālā,[19] of which the earliest dated manuscript was copied in 1697. Kṛṣṇadāsa,[20] a protégé of Akbar, wrote a Pārasīprakāśa[21] in about 1575. This work consists of two parts: a Persian-Sanskrit dictionary (including terms relating to the heavens, to the directions, and to time), and a Persian grammar in Sanskrit. This, however, was entirely insufficient for translators of Persian astronomical and astrological works into Sanskrit; so, in 1643, Mālajit,[22] who received the title Vedāṅgarāya from Shāh Jahān, wrote his Pārasīprakāśa at Śrīsthala in Gujarāt. In consideration of the numerous translations made from Persian and Arabic, both in the Mughal period and before, one must conclude that many other aids were available. The one that we are definitely informed of is the bilingual Muḥammad Ābidda who assisted Nayanasukhopādhyāya; and it should also be noted that many Persian technical terms used by al-Qūshjī are given their Sanskrit equivalents in the Hayatagrantha.

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[18] Published with a Telugu *ṭīkā*, Madras 1908; Cocanada 1926; with an English translation by V. Subrahmanya Sastri, Bangalore 1939, 2nd edition Bangalore 1951; and with Jagannātha Bhasīna's Hindī *ṭīkā*, Delhi 1971.

[19] Published by Mannālāla Paṇḍita in his Dvādaśakośānāṃ saṅgraha, Vārāṇasī 1865.

[20] CESS A 2, 57a—57b, and A 4.

[21] Edited by A. Weber, "Über den Pārasīprakāça des Kṛishṇadāsa," AAWB (1887), Phil.-hist. Kl. 1, and "Über den zweiten, grammatischen, Pārasīprakāça dés Kṛishṇadāsa," AAWB (1888), Phil.-hist. Kl. 3; and by V. Bhaṭṭācārya as SBG 95, Benares 1965.

[22] CESS A 4.

Chapter IX

TRANSMISSION OF JYOTIḤŚĀSTRA

At present there exist in India and outside of it some 100,000 manuscripts on the various aspects of *jyotiḥśāstra*. The great majority of these were copied within the seventeenth, eighteenth, and nineteenth centuries; for manuscripts cannot long survive in India except under exceptional circumstances. We have, therefore, essentially only those texts selected for study or composed by the scholars of the Mughal and British *rājyas*. Since the practice of copying manuscripts is virtually dead in modern India, many of these estimated 100,000 manuscripts will soon disappear, and the possibilities of our achieving a reasonably accurate assessment of the continuity, development, and transformation of the astral and mathematical sciences in India will be correspondingly diminished. But even without this appalling prospect, we must constantly be aware of the arbitrary way in which was made the selection of texts and commentaries preserved in today's libraries.

For manuscripts were preserved, with some exceptions, in India before the nineteenth century in family libraries. It is true that Anūpasiṃha,[1] the Mahārāja of Bikaner in Rājasthān from 1674 till 1698, formed a vast collection rich in *jyotiḥśāstra* manuscripts (many from the Deccan, where he campaigned with Aurangzib) that still survives intact in the Anup Sanskrit Library; that the core of the Sarasvatī Mahal Library in Tanjore goes back to Tulajarāja,[2] the Mahārāja of Tanjore from 1728 till 1736, and his predecessors; that, at the same time, Savāī Jayasiṃha collected some of the manuscripts now in the Jayapura Museum; and that the incredible treasures of a number of the ancient Jaina Bhāṇḍāras of Gujarāt and Rājasthān have been accumulating since the twelfth and thirteenth centuries. Still, most of our manuscripts were in small private collections till recently—or still are. And these small collections tend to preserve a few of the accepted astronomical works of the region (if the family produces *pañcāṅgas*) and the standard works on *jātaka*, *tājika*, *muhūrta*, *praśna*, and *saṃhitā* (if they are astrologers); beyond this they might contain locally popular works, or even manuscripts—sometimes unique—of treatises composed by members of their own families. Since education in the *śāstra* was through a *guru* normally rather than through a *pāṭhaśālā* or *maṭha*, the enrichment of these family libraries was probably most common when a son was sent to study with an external *guru;* one of the most notable examples of this that we have is

[1] CESS A 1, 43b—44a.
[2] CESS A 3, 87b—88b.

Divākara of Golagrāma, whose family we shall soon discuss. In large cultural centers like Kāśī, of course, intercourse was easier. And Jaina monks in their ordained peregrinations spread both learning and manuscripts. It was a recognized pious act for a Jaina layman to bear the expense of the copying of manuscripts for these monks; and many of them, as we know from their colophons, occupied the rainy seasons with scribal work.

It is clear, then, that chance has to a large extent determined what has survived of the truly immense body of material on *jyotiḥśāstra* that has existed in the past. As an example of this, let us examine the members of the Girināràyaṇajñāti[3] of Gujarāt, who are known primarily because much of their family library was included in the gift of manuscripts presented to the East India Company by the Gaikawar of Baroda in 1809.[4] Many of them copied extant manuscripts (their names are followed by S), and some were authors of original works (see Table 7). Though there are several gaps at present in our knowledge of the precise relationship of several generations of this family, it is clear that they were active as scribes and authors from about 1500 till 1750; and that, if their library had not been preserved by the Gaikawar's gift, we would not know of the Gaṇitacūḍāmaṇi of Harihara or the Grahavidyādhara of Vidyādhara (there is just one other manuscript of his Pañcāṅgavidyādharī besides that in the family collection), and a number of the relatively rare works would be attested by an even smaller number of extant copies.

Another case that it is instructive to examine is that of the family which produced the great Bhāskara in the twelfth century (see Table 8[5]) and which lived in the Sahyādri range, though we possess no manuscripts from their family library. That library presumably was part of the endowment of the *maṭha* established by Soīdeva under the Yādava Siṅghaṇa at Pāṭṇā in Khandesh in 1207 for the study of the works of Bhāskara; Bhāskara's grandson, Caṅgadeva, was one of Siṅghaṇa's court astrologers, as was also Bhāskara's nephew's son, Anantadeva. It is regrettable, then, that we no longer have either of Anantadeva's works or his great grandfather, Maheśvara's, Karaṇaśekhara. However, we do have one treatise that may well have been written by a student of the *maṭha;* this is the Laghukhecarasiddhi composed by Śrīdhara in 1227, a rare work of which one of the three available manuscripts was copied by Nīlakaṇṭha of the Girināràyaṇajñāti at Jīrṇadurga in 1555.

Whatever the fate of the *maṭha* and its library after the fall of Devagiri in 1312, the region was particularly fertile in producing families of *jyotiṣīs* who

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[3] SATE, pp. 186—188.

[4] D. Pingree, Śrīdhara's Laghukhecarasiddhi, Baroda 1976, pp. 10—16.

[5] The earliest known member of the family, Trivikrama, is sometimes identified with the author of the Damayantīkathā, who was the son of Nemāditya, the son of Śrīdhara of the Śāṇḍilyagotra. However, this identification is unlikely since Trivikrama the son of Nemāditya composed the Navasāri grant of Rāṣṭrakūṭa Indra III in 915, while our Trivikrama's son Bhāskara was honored by Bhojarāja a century later.

were proud to preserve their lineages. One center of activity was Pārthapura on the Godāvarī, which has been identified with Pathri in the Parbhani District some eighty miles southeast of Devagiri, whose Muslim lord ruled the area for much of the medieval period. In Pārthapura flourished from about 1300[6] the family that produced Jñānarāja, Sūryadāsa, and others (see Table 9). In keeping with the traditions of the region, several members of this family wrote works dependent on those of Bhāskara; their family library clearly contained copies of his opera. We are lucky to have a partial genealogy of the descendents of Sūryadāsa provided by one of them in 1895.[7] Sūryadāsa's great-grandson in this lineage was a Gopāla, who lived from 1623 till 1668. He is not identical with the father of Vīreśvara (see Table 10), a fellow resident of Pārthapura, since Vīreśvara was old enough to comment on Bhāskara's L in 1639; but he may be a cousin (perhaps once or several times removed). Some of the manuscripts belonging to this family could be ascertained by a careful examination of their works; whether or not Vīreśvara had access to the same library might be then determined by reading his commentaries and other treatises.

In a village in the district *(deśa)* of Pārthapura named Golagrāma another family of the Bhāradvājagotra began its career in the middle of the fifteenth century (see Table 11); it is linked to the family we have just discussed by the fact that one of Vīreśvara's works is a commentary on one of Divākara's astrological treatises. However, its history is quite different; for in the early sixteenth century that Divākara's great-grandfather, also named Divākara, went to Nandigrāma to study with the famous Gaṇeśa (see Table 12). From Gujarāt he evidently travelled to Kāśī, where his descendents became one of the two prominent families of *jyotiṣīs* in the seventeenth century. Divākara presumably brought with him copies of his *guru's* works and those of his *guru's* father, Keśava; and we find that a considerable portion of the scholarly energy of the family was devoted to explicating the various treatises of Keśava and Gaṇeśa. However, following the local preference in Kāśī, they also expounded the Saurapakṣa; and they were receptive to some elements of Islamic astronomy.

The rival family in Kāśī (see Table 13) in the seventeenth century originated at Dadhigrāma on the Payoṣṇī to the northwest of Pārthapura; for Munīśvara places it near Gaṅgābhaiśilanagara near the Godāvarī (perhaps Gangapur in the Aurangabad District), in the district *(samadeśa)* of Elavapura (Ellora). The Payoṣṇī on whose bank Dadhigrāma lies, then, must be the Pūrṇa that eventually flows into the Godāvarī some thirty miles to the east of Pārthapura, though Dadhigrāma would have been near the headwaters, just south of Bhāskara's Sahyādri range. This family traces its history back to the middle of the fifteenth century also, and moved to Kāśī in the late sixteenth century. Its interests were divided between Bhāskara's works, the Saurapaksa, and

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[6] Gaṇeśa puts the origin of his family under Rāma the lord of Devagiri, who must be the Yādava Rāmacandra, who ruled from 1271 till 1311.

[7] CESS A 3, 75a—75b.

Gaṇeśa's works, while some of its members vehemently attacked members of the Golagrāma family for their acceptance of Islamic astronomical theories. Another family (see Table 14) that flourished in the same area came originally from an unidentified place called Sāsamaṇūra, but had settled in Ṭāpara to the north of Devagiri in the late sixteenth century.

One last case may be considered to illustrate the influx of *jyotiṣīs* from Vidarbha into Kāśī in the sixteenth century. This family (see Table 15) originated at Dharmapura on the Narmadā in the early part of that century, but became prominent—primarily as astrologers—at Kāśī toward the end of the century.

This pattern of families of *jyotiṣīs* equipped with their own libraries that we can trace in some instances over several centuries was not the norm in South India, though family connections there also obviously had a strong influence. The area that is best known is Kerala, where libraries were maintained at the family *illam*, but where new members of the "school" were often recruited from outside the family. The most impressive line is that of Parameśvara[8] (see Table 16); it can be continued from Acyuta to the middle of the nineteenth century.[9] Other, lesser lines are known from Kerala; unfortunately, our information from other Dravidian-speaking areas is not detailed enough to discern any such pattern (but see Table 17).

However, the continuation of these traditions throughout India was, of course, due not only to the transmission of learning from father to son or from *guru* to *śiṣya;* it was also actively cultivated by the patronage of the powerful—usually Mahārājas. Thus the court of Paramāra Bhojarāja at Dhārā produced a number of *jyotiṣa* treatises under the Mahārāja's name in the early eleventh century, and provided encouragement to Bhāskara's great-great-great-grandfather, and probably to Daśabala as well. Mughal patronage of Sanskrit works on *jyotiṣa* in the sixteenth and seventeenth century was extremely generous.[10] And, of course, various of the courts of Rājasthān in the same period—and into the nineteenth century in some cases—maintained *jyotiṣīs*, many of whom became authors. But a more interesting development occurred in Gujarāt under the Caulukyas. A number of their leading state officials or members of their families, belonging primarily to the Prāgvāṭavaṃśa (see Tables 18, 19, and 20), though there are also some who belonged to the Janyālayakula (see Table 21), wrote on *jyotiṣa.* The reasons for this phenomenon are not apparent. Naturally, other scholars worked in this field under the Caulukyas who were not members of ministerial families; such are the Jaina Naracandropādhyāya, who composed one of his works at Campāvatī in 1167 under Caulukya Kumārapāla, and

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[8] See K. V. Sarma, "Direct Lines of Astronomical Tradition in Kerala," Charudeva Shastri Felicitation Volume, Delhi 1974, pp. 601—604.

[9] K. V. Sarma, A History of the Kerala School of Hindu Astronomy, VIS 55, Hoshiarpur 1972, pp. 5—6.

[10] M. M. Patkar, "Moghul Patronage to Sanskrit Learning," PO 3 (1938), 164—175.

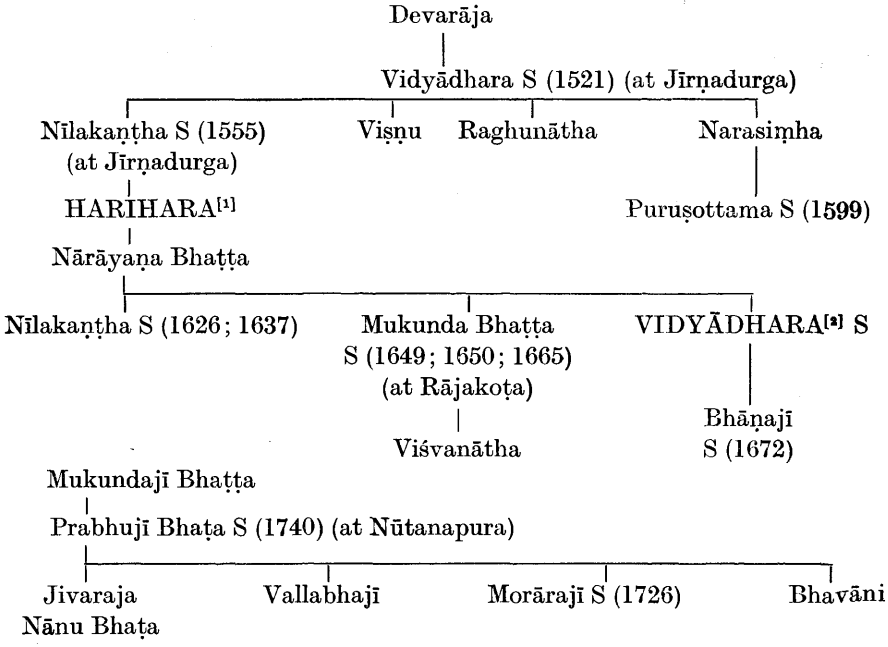
Narapati, the son of Naradeva of Dhārā, who completed the Narapatijayacaryā at Aṇahilanagara in 1177 under Caulukya Ajayapāla.

But there was another relationship that we can observe in Gujarāt in this period. Jaina monks such as Naracandropādhyāya often became authors of *jyotiṣa* texts; but we usually are ignorant of the intellectual climate and economic situation under which they labored. Vastupāla, the minister of Caulukya [Vāghela] Vīradhavala and Visaladeva at Dhavalakka (Dholkā, Gujarāt) from 1220 till his death in 1240 and a Jaina member of the Prāgvāṭavaṃśa, was a great patron of Jaina scholars,[11] among whom were numbered two *jyotiṣīs:* Udayaprabha Sūri and Naracandra Sūri. The extent to which these men, or others, Jaina or Hindu, who received princely rewards for their scientific activities, were encouraged and assisted by the milieus provided by their patrons must have varied from individual to individual. But it must be recognized that this patronage of scholars by the powerful, sporadic as it was (it seems to have been more frequent and sustained over longer periods in Gujarāt and Rājasthān than elsewhere in India), served as an alternative mode for the intermingling of traditions, the production of new works, and the copying and preservation of manuscripts to the more traditional family libraries and Jaina *bhāṇḍāras*. When CESS is completed, it will be possible to analyze the surviving evidence concerning who copied manuscripts (often we observe families of scribes functioning for as many generations as the families of *jyotiṣīs*) and who owned them. Until then I leave the question at this point.

[11] B. J. Sandesara, **Literary Circle of Mahāmātya Vastupāla and its Contribution to Sanskrit Literature, SJS 33, Bombay 1953.**

Table 7

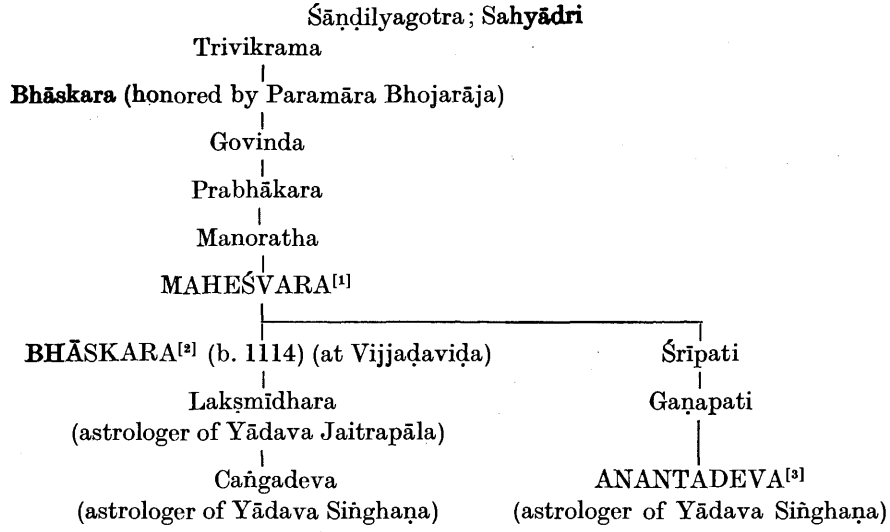
Vasiṣṭhagotra, Girinārāyaṇajñāti; Gujarāt



[1] Gaṇitacūḍāmaṇi.

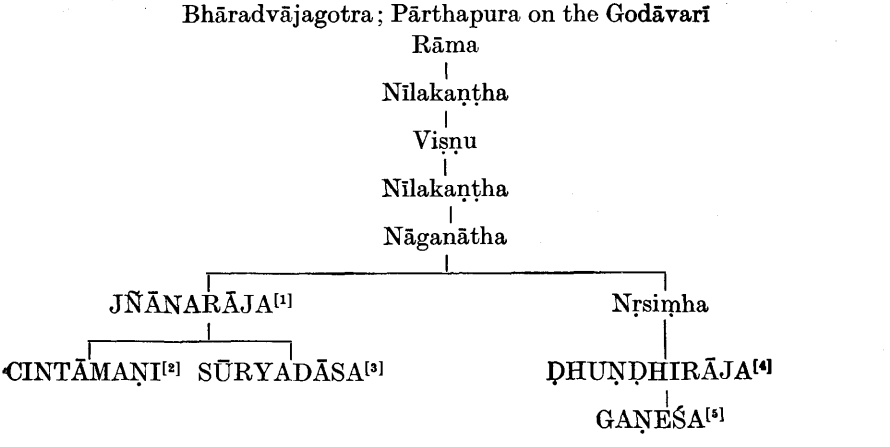
[2] Grahavidyādhara (at Rājakoṭa 1638); Pañcāṅgavidyādharī (at Jīrnagaḍha 1643).

Table 8



[1] Vṛttaśataka; Laghujātakaṭīkā; Karaṇaśekhara.
[2] Līlāvatī; Bījagaṇita; Siddhāntaśiromaṇi (1150; with *ṭīkā*, Mitākṣarā); Karaṇakutūhala (1183); Śiṣyadhīvṛddhidavivaraṇa.
[3] Chandaścittyuttarādhyāyaṭīkā; Bṛhajjātakaṭīkā.

Table 9



[1] Siddhāntasundara (1503); Bījādhyāya.
[2] Grahagaṇitacintāmaṇi.
[3] Sūryaprakāśa (1538); Tājikālaṅkāra; Gaṇitāmṛtakūpikā (1541); Siddhāntasaṃhitāsārasamuccaya; Bhāskarabhūṣaṇa.
[4] Jātakābharaṇa.
[5] Tājikabhūṣaṇa; Ratnāvalīpaddhati; Gaṇitamañjarī.

Table 10

Pārthapura
Vināyaka
|
Gopāla
|
VĪREŚVARA[1]

[1] **Līlavatyudāharaṇa (1639)**; Bījavivaraṇa ?; **Divākarapaddhatiprakāśavivaraṇa ?; Tithyāvali ?**; Tājikābharaṇa ?

Table 11

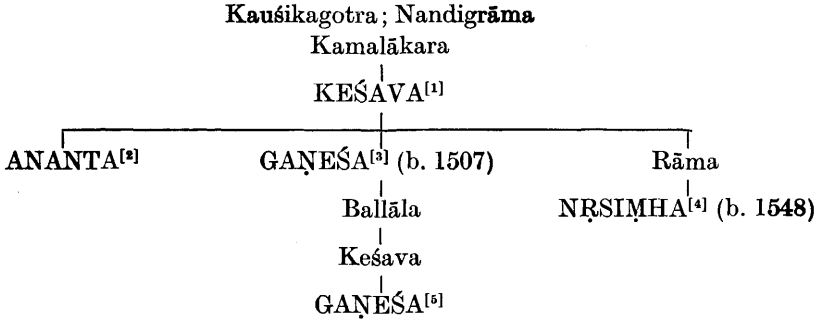
Bhāradvājagotra; Golagrāma **on the Godāvarī**

Rāma
|
Bhaṭṭācārya
|
Divākara (pupil of Gaṇeśa of Nandigrāma; to Kāśī)

Kṛṣṇa — VIṢṆU[1] — MALLĀRI[2] — Keśava — VIŚVANĀTHA[3]
NṚSIṂHA[4] (b. 1586) — TRYAMBAKA[5]
DIVĀKARA[6] (b. 1606) — KAMALĀKARA[7] — RAṄGANĀTHA[8]

[1] Bṛhaccintāmaṇiṭīkā; Saurapakṣagaṇita ? (1608).
[2] Grahalāghavaṭīkā; Parvadvayasādhana ? (1588); Varṣaphalapaddhatiṭīkā ?
[3] Siddhāntarahasyodāharaṇa (1612); Brahmatulyodāharaṇa (1612); Rāmavinodadīpikā (1614); Keśavīpaddhatyudāharaṇa (1618); Gahanārthaprakāśikā (1620); Nīlakaṇṭhyudāhṛti (1629); Pātasāraṇīṭīkā (1631); Karaṇaprakāśodāharaṇa; Janmapatrīlekhanakrama; Tithicintāmaṇiṭīkā; Makarandodāharaṇa; Mitāṅka; Muhūrtatattvaṭīkā; Varṣaphalapaddhatiṭīkā; Saurapakṣagaṇitavyākhyā.
[4] Saurabhāṣya (1611); Vāsanāvārttika (1621); Tithicintāmaṇiṭīkā.
[5] Viṣṇukaraṇaṭīkā (1663); Paddhatikalpavallī (1673).
[6] Jātakamārga (1625; with *ṭīkā* in 1627); Prauḍhamanoramā (1626); Makarandavivaraṇa; Pātasāraṇīṭīkā; Varṣagaṇitabhūṣaṇa (with *ṭīkā*).
[7] Siddhāntatattvaviveka (1658; with *ṭīkā*); Śeṣavāsanā; Sauravāsanā.
[8] Mitabhāṣiṇī; Lohagolakhaṇḍana; Palabhākhaṇḍana; Bhaṅgīvibhaṅgīkaraṇa.

Table 12



[1] Grahakautuka (1496); Jātakapaddhati (with *ṭīkā*); Tājikapaddhati; Muhūrtatattva; Sudhīrañjana.

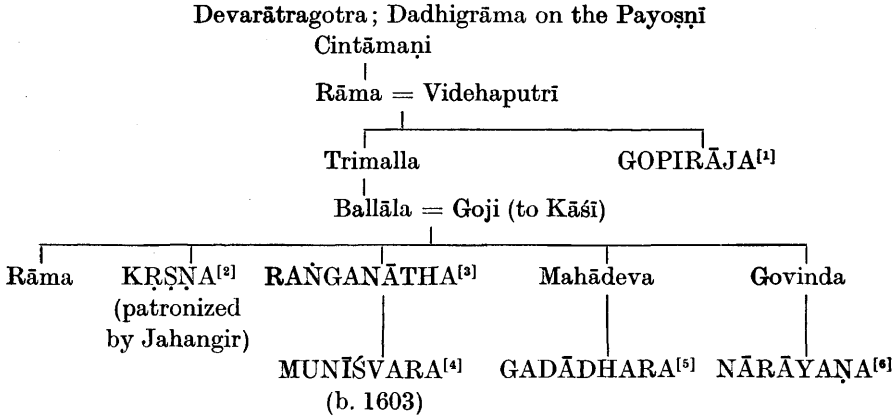
[2] Laghujātakaṭīkā.

[3] Grahalāghava (1520); Pātasāraṇī (1522); Tithicintāmaṇi (1525); Buddhivilāsinī (1545); Bṛhattithicintāmaṇi (1552); Vivāhadīpikā (1554); Muhūrtadīpikā; Cābukayantra; Pratodayantra (with *ṭīkā*); Sudhīrañjanayantra.

[4] Grahakaumudī (1588 and 1603); Kheṭamuktāvalī (1566); Grahadaśāphala; Grahadīpikā; Varṣaphaladīpikā; Harṣakaumudī; Hillājadīpikā.

[5] Śiromaṇiprakāśa.

Table 13



[1] Perhaps the resident of Dadhigrāma who wrote the Vilāsavatī (1540).

[2] Bījāṅkura (1601 ?); Jātakapaddhatyudāharaṇa.

[3] Gūḍhārthaprakāśaka (1603).

[4] Marīci (before 1638); Siddhāntasārvabhauma (1646; with a *ṭīkā*, Āśayaprakāśinī, in 1650); Ekanāthamukhabhañjana; Gaṇitaprakāśa; Cābukayantraṭīkā; Pāṭīsāra; Nisṛṣṭārthadūtī.

[5] Lohagolasamarthana.

[6] Grahalāghavodāhṛti; Jātakakaustubha (1678).

Table 14

Kauśikagotra; Sāsamaṇūra

Ananta
|
Kṛṣṇa
|
Hari
|
Ananta
|
NĀRĀYAṆA[1] (at Ṭāpara)
|
GAṄGĀDHARA[2]

[1] Muhūrtamārtaṇḍa (1571; with *ṭīkā* in 1572).
[2] Manoramā (1586).

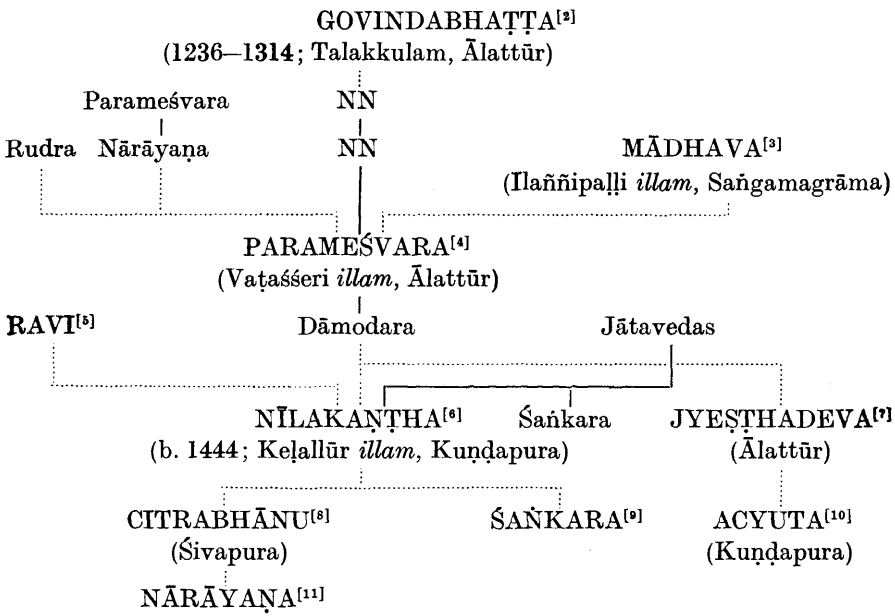
Table 15

Gārgyagotra; Dharmapura on the Narmadā

Cintāmaṇi
|
ANANTA[1] = Padmāmbā
|
NĪLAKAṆṬHA[2] (at Kāśī) — RĀMA[3] (at Kāśī)
|
GOVINDA[4] (b. 1569)
|
CINTĀMAṆI[5]

[1] Kāmadhenuṭīkā; Janipaddhati.
[2] Jyotiṣasaukhya (1572); Vivāhasaukhya; Vāstusaukhya; Vyavahārasaukhya; Saṃskārasaukhya; Samayasaukhya; Tājikanīlakaṇṭhī (1587); Praśnakaumudī; Bhāvaprakāśa.
[3] Rāmavinoda (1590; 2 versions); Muhūrtacintāmaṇi (1600; with *ṭīkā*, Pramitākṣarā).
[4] Pīyūṣadhārā (1603); Rasālā (1622); Bhāvavivṛti.
[5] Saṃmaticintāmaṇi (1661).

Table 16[1]



[1] Continuous lines represent the relation of father and son, dotted lines that of teacher and pupil.

[2] Daśādhyāyī; Muhūrtaratna.

[3] Sphuṭacandrāpti; Veṇvāroha (1403); Agaṇitagrahacāra (1418); Candravākyāni; Madhyamānayanaprakāra; Mahājyānayanaprakāra; Lagnaprakaraṇa; Golavāda ?

[4] Laghubhāskarīyaṭīkā (1408); Laghumānasaṭīkā (1409); Grahaṇamaṇḍana (1411); Dṛggaṇita (1431); Siddhāntadīpikā; Grahaṇanyāyadīpikā; Goladīpikā I (1443; with a *ṭīkā*); Grahaṇāṣṭaka; Vākyakaraṇa; Bhaṭadīpikā; Līlāvatīvivaraṇa; Mahābhāskarīyaṭīkā; Sūryasiddhāntavivaraṇa (1432); Goladīpikā II (with an expanded version); Jātakapaddhati; Vyatipātāṣṭakavṛtti; Ācārasaṅgraha; Muhūrtaratnavyākhyā; Jātakakarmapaddhatiṭīkā; Ṣaṭpañcāśikāṭīkā; Candracchāyāgaṇita; Vivāhānukulya; Ṣaḍvargaphala.

[5] Ācāradīpikā.

[6] Golasāra; Siddhāntadarpaṇa (with *ṭīkā*); Candracchāyāgaṇita (with *ṭīkā*); Tantrasaṅgraha (1501); Āryabhaṭīyabhāṣya; Jyotirmīmāṃsā (1504); Grahaṇanirṇaya; Sundararājapraśnottara.

[7] Yuktibhāṣā; Dṛkkaraṇa ? (1608).

[8] Karaṇāmṛta (1530).

[9] Tantrasaṅgrahaṭīkā (1556); Kriyākramakarī (incomplete).

[10] Karaṇottama (with *ṭīkā*); Uparāgakriyākrama (1593); Sphuṭanirṇaya; Chāyāṣṭaka; Uparāgaviṃśati; Rāśigolasphuṭānīti; Veṇvārohavyākhyā; Horāsāroccaya.

[11] Pañcabodhaṭīkā (1529); Uparāgakriyākrama; Karmapradīpikā; Karaṇasūraṭīkā; completion of Śaṅkara's Kriyākramakarī.

Table 17

GOVINDA DĪKṢITA
(minister of Acyutappa Nāyaka of Tanjore [1560—1600])

Yajñanārāyaṇa Dīkṣita — VEṄKAṬEŚVARA DĪKṢITA[1]

VEṄKAṬEŚVARA[2]

[1] Śulbamīmāṃsā.
[2] Jātakacandrikā.

Table 18

Prāgvāṭavaṃśa; Gujarāt
Āhilla or Jāhilla
(minister of Caulukya Bhīma I [ca. 1031—1065])

Rājapāla

Narasiṃha

DURLABHARĀJA[1]
(mahattama under Caulukya Kumārapāla [ca. 1143—1152])

JAGADDEVA[2]

[1] Sāmudrikatilaka.
[2] Svapnacintāmaṇi.

Table 19

Prāgvāṭavaṃśa; Gujarāt
Caṇḍasiṃha
(minister of Caulukya Mūlarāja II [ca. 1177—1179])

Śobhanadeva

Sāmanta

Kumārasiṃha

SAMARASIṂHA[1]

[1] Tājikatantrasāra (1274).

Table 20

Prāgvāṭavaṃśa; Gujarāt
Vikrama
(minister of Caulukya [Vāghela] Śāraṅgadeva [ca. 1276–1296])

TEJAḤSIṂHA[1] — Vijayasiṃha

[1] Daivajñālaṅkṛti (1336).

Table 21

Janyālayakula; Ānandapura, Gujarāt
Bandhuka
(minister of Caulukya Karṇa [ca. 1066–1093])

Mahādeva

ĀMAŚARMAN[1] — Lūṇiga — Arjuna (minister of Caulukya Bhīma II [ca. 1178–1241])

Lūṇiga
MAHĀDEVA[2]

[1] Vāsanābhāṣya.
[2] Cintāmaṇisāraṇikāvivṛti (1258); Jyotiṣaratnamālāvivṛti (1264).

ABBREVIATIONS

A. Books, Series, and Journals

AAWB	Abhandlungen der Akademie der Wissenschaften zu Berlin
ABORI	Annals of the Bhandarkar Oriental Research Institute
AfO	Archiv für Orientforschung
AHES	Archive for History of Exact Sciences
AIHS	Archives internationales d'histoire des sciences
ALPS	Adyar Library Paper Series
ALS	Adyar Library Series
AMM	American Mathematical Monthly
Arch Or	Archiv Orientalní
ASI, NIS	Archaeological Survey of India, New Imperial Series
ASS	Ānandāśrama Sanskrit Series
BCMS	Bulletin of the Calcutta Mathematical Society
BI	Bibliotheca Indica
BM	Bibliotheca Mathematica
BNISI	Bulletin of the National Institute of Sciences of India
Bombay SS	Bombay Sanskrit Series
BSS	Benares Sanskrit Series
BVKSGWL	Berichte über die Verhandlungen der Königlich Sächsischen Gesellschaft der Wissenschaften zu Leipzig
CESS	D. Pingree, Census of the Exact Sciences in Sanskrit, Series A, vol. 1—3, Philadelphia 1970—1976; vol. 4 is in press
CSS	Chowkhamba Sanskrit Series
DSB	Dictionary of Scientific Biography
EW	East and West
Ganga OS	Ganga Oriental Series
GOS	Gaekwad Oriental Series
HM	Historia Mathematica
HNM	Harikṛṣṇanibandhamaṇimālā
HOS	Harvard Oriental Series
HSS	Haridas Sanskrit Series
IC	Islamic Culture
IIJ	Indo-Iranian Journal
IJHS	Indian Journal of the History of Science
IS	Indische Studien
JAOS	Journal of the American Oriental Society
JAS Bengal	Journal of the Asiatic Society of Bengal
JBBRAS	Journal of the Bombay Branch of the Royal Asiatic Society
JBORS	Journal of the Bihar and Orissa Research Society
JDL/UC	Journal of the Department of Letters, University of Calcutta
JHA	Journal for the History of Astronomy
JHAS	Journal for the History of Arabic Science
JJG	Jīvarāma Jaina Granthamālā
JMJSG	Jñānapīṭha Mūrtidevī Jaina Saṃskṛta Granthamālā
JNES	Journal of Near Eastern Studies
JOI Baroda	Journal of the Oriental Institute, Baroda
JOR Madras	Journal of Oriental Research, Madras

JRAS	Journal of the Royal Asiatic Society
JRASB/S	Journal of the Royal Asiatic Society of Bengal, Science
JUB	Journal of the University of Bombay
JUPHS	Journal of the United Provinces Historical Society
JWCI	Journal of the Warburg and Courtauld Institutes
KSS	Kāśī Sanskrit Series
KSVS	Kendrīya Saṃskṛta Vidyāpīṭha Series
LG	Laghu Granthamālā
Madras GOS	Madras Government Oriental Series
ME	Mathematics Education
MJG	Mohanalālajījainagranthamālā
MM	Master Maṇimālā
MPAWB	Monatsberichte der Preußischen Akademie der Wissenschaften zu Berlin
MS	The Mathematics Student
MSS	Mysore Sanskrit Series
MSVG	Mithilā Saṃskṛta Vidyāpīṭha Granthamālā
NIA	New Indian Antiquary
PAIOC	Proceedings of the All-India Oriental Conference
PAPhS	Proceedings of the American Philosophical Society
PBMS	Proceedings of the Benares Mathematical Society
PKG	Prācyavidyāsaṃśodhanālayakannaḍagranthamālā
PO	Poona Orientalist
POS	Poona Oriental Series
PST	Pracyavani Sanskrit Texts
PTSS	Prakrit Text Society Series
PUIS	Panjab University Indological Series
PWSBT	Princess of Wales Sarasvati Bhavana Texts
RPG	Rājasthāna Purātana Granthamālā
RSG	Ravi Varma Sanskrita Granthavali
RUMJ	Ranchi University Mathematical Journal
SATE	D. Pingree, Sanskrit Astronomical Tables in England, Madras 1973
SATIUS	D. Pingree, Sanskrit Astronomical Tables in the United States, Philadelphia 1968
SBG	Sarasvatī Bhavana Granthamālā
SJS	Singhi Jain Series
SM	Scripta Mathematica
TRAS	Transactions of the Royal Asiatic Society
TSMS	Tanjore Saraswathi Mahal Series
TSS	Trivandrum Sanskrit Series
VIJ	Vishveshvaranand Indological Journal
VIS	Vishveshvaranand Indological Series
VSG	Vidyābhavanasaṃskṛtagranthamālā
VSS	Vizianagram Sanskrit Series
ZDMG	Zeitschrift der Deutschen Morgenländischen Gesellschaft

B. Titles of Sanskrit texts

A	Āryabhaṭīya
BBS	Bhadrabāhusaṃhitā
BG	Bījagaṇita
BJ	Bṛhajjātaka
BPH	Bṛhatpārāśarahorā
BS	Bṛhatsaṃhitā

BSS	Brāhmasphuṭasiddhānta
BY	Bṛhadyātrā
GCN	Grahacāranibandhana
GK	Gaṇitakaumudī
GL	Grahalāghava
GS	Gargasaṃhitā
GT	Gaṇitatilaka
H	Horāsāra
HM	Horāmakaranda
JKP	Jātakakarmapaddhati
JN	Jyotirnibandha
JP	Jātakapaddhati
JPJ	Jātakapārijāta
JRM	Jyotiṣaratnamālā
JSD	Jātakasāradīpa
JV	Jyotiṣavedāṅga
Kh	Khaṇḍakhādyaka
KK	Karaṇakutūhala
KKK	Karaṇakaustubha
KS	Karaṇasāra
L	Līlāvatī
LB	Laghubhāskarīya
LJ	Laghujātaka
LM	Laghumānasa
MB	Mahābhāskarīya
MC	Muhūrtacintāmaṇi
MG	Muhūrtagaṇapati
MM	Muhūrtamārtaṇḍa
MS	Mahāsiddhānta
NJ	Narapatijayacaryā
NS	Nāradasaṃhitā
Pait.	Paitāmahasiddhānta of the Viṣṇudharmottarapurāṇa
PhD	Phaladīpikā
PJ	Praśnajñāna
PS	Pañcasiddhāntikā
RM	Rājamṛgāṅka
RV	Rāmavinoda
S	Sārāvalī
ŚB	Śatapathabrāhmaṇa
ŚDV	Śiṣyadhīvṛddhida
SR	Siddhāntarāja
SS	Sūryasiddhānta
SŚB	Siddhāntaśiromaṇi
SSBM	Siddhāntasārvabhauma
SSJ	Siddhāntasundara
SŚŚ	Siddhāntaśekhara
STV	Siddhāntatattvaviveka
ṬY	Ṭikanikayātrā
VM	Vidyāmādhavīya
VS	Vaṭeśvarasiddhānta
VSA	Vasiṣṭhasaṃhitā
VYJ	Vṛddhayavanajātaka
YJ	Yavanajātaka
YY	Yogayātrā

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